The relationship between connective tissue abnormality and pelvic floor dysfunction

A thesis submitted to the University of Manchester for the degree of Doctor of Medicine in the faculty of Medical and Human Sciences

2013

Gemma Faulkner

School of Medicine

Contents

Final word count 56,381

List of Figures

List of Tables

List of Appendices

Abstract

The University of Manchester, Doctor of Medicine, February 2013
Gemma Faulkner

The relationship between connective tissue abnormality and pelvic floor dysfunction

Perineal descent (PD) is a sign of connective tissue weakness of the pelvic floor, it can be measured mechanically or radiologically. Joint hypermobility can be a sign of a generalised connective tissue abnormality, there is an increased incidence of pelvic organ prolapse and faecal incontinence amongst patients with heritable connective tissues diseases. To explore the relevance of PD and the relationship between connective tissue abnormality and pelvic floor dysfunction five studies were performed.

A new mechanical device for the measurement of PD, the laser commode, and the established mechanical device, the perineometer were compared to the current gold standard method of measurement, defaecating proctography in 68 subjects. The laser commode provided a mean overall PD measurement closer to that of proctography than the perineometer but the repeatability and reproducibility of the measurements were not accurate enough for the laser commode to be used either in the subsequent parts of this research project or in a clinical setting.

Perineal descent was measured using proctography and joint hypermobility was measured using the Beighton score in 70 females with pelvic floor dysfunction. No correlation was found between PD and joint mobility.

A review of 323 proctograms of females with pelvic floor dysfunction found an association between PD and rectal prolapse but no association between either PD and rectocele formation or PD and rectal intussusception. The Pelvic Floor Distress Inventory questionnaires of 133 females were correlated with their proctography findings. There was no association between PD and any of the clinical symptoms.

Biopsies from the rectus sheath and pelvic floor fascia of 19 females with rectal prolapse were compared to those of 8 normal controls. There was no difference in collagen or elastin content between the groups but participant numbers were small. The pelvic floor fascia of the rectal prolapse group showed a higher percentage of well organised elastin than that of the control group but this did not reach statistical significance.

Perineal descent does not appear to be a consistent indicator of severe pelvic floor connective tissue abnormality or injury. This study has furthered our understanding of perineal descent and the relationships between this finding and other pelvic floor disorders caused by connective tissue weakness. Future work will focus on further histological analysis of tissue from patients with rectal prolapse in combination with the use of more sensitive methods to establish the presence of an underlying connective tissue abnormality.

Declaration

I declare that no part of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

COPYRIGHT STATEMENT

i. The author of this thesis (including any appendices and/or schedules to this thesis) owns certain copyright or related rights in it (the "Copyright") and s/he has given The University of Manchester certain rights to use such Copyright, including for administrative purposes.

ii. Copies of this thesis, either in full or in extracts and whether in hard or electronic copy, may be made **only** in accordance with the Copyright, Designs and Patents Act 1988 (as amended) and regulations issued under it or, where appropriate, in accordance with licensing agreements which the University has from time to time. This page must form part of any such copies made.

iii. The ownership of certain Copyright, patents, designs, trade marks and other intellectual property (the "Intellectual Property") and any reproductions of copyright works in the thesis, for example graphs and tables ("Reproductions"), which may be described in this thesis, may not be owned by the author and may be owned by third parties. Such Intellectual Property and Reproductions cannot and must not be made available for use without the prior written permission of the owner(s) of the relevant Intellectual Property and/or Reproductions.

iv. Further information on the conditions under which disclosure, publication and commercialisation of this thesis, the Copyright and any Intellectual Property and/or Reproductions described in it may take place is available in the

University IP Policy (see http://www.campus.manchester.ac.uk/medialibrary/policies/intellectual-property.pdf), in any relevant Thesis restriction declarations deposited in the University Library, The University Library's regulations (see http://www.manchester.ac.uk/library/aboutus/regulations) and in The University's policy on presentation of Theses

Dedication

To Amabel and Helen, the other two.

Acknowledgements

I am sincerely grateful to Mr Edward Kiff, my research supervisor, who has provided guidance and support throughout this work. I would like to express my thanks to the General Surgical and Gynaecology Consultants at the University Hospital of South Manchester for allowing me to recruit their patients, in particular Miss Karen Telford, Mrs Sarah Duff and Miss Toli Onon.

I am indebted to Professor Derrick Martin, Mrs Andrea Owen and Dr Kandise Jackson who played major roles in helping with the radiology side of this project.

I am very grateful to Catherine Keeling and Robyn Davies for their assistance and technical skills in the laboratory and Professor Tony Freemont for his expert and enthusiastic approach to examining the biopsy specimens. Thanks also to Julie Morris for her statistical advice and to Professor Anne White, my MD advisor.

Thank you to Ben Hornung, Peter Mitchell, Kirsty Cattle and Karen Rose, my fellow research colleagues for their advice, support and constant good humour. I would like to thank all of the patients who inspired this research and gave up their time to take part.

Finally thank you to my parents and brothers and to my best friends, Amabel, Helen and Lovleen for their unending patience, understanding and motivation which has enabled me to overcome the challenges of this project.

Duration of research period:

5th August 2009-4th October 2011

Duration of data collection:

The commencement of data collection was delayed because of difficulties in obtaining ethical approval, this was not granted by the Greater Manchester West Regional Ethics Committee on two occasions (August 2010 and October 2010). The research protocol was revised and separate applications for each of the three studies which required ethical approval were re-submitted.

A novel device for the measurement of perineal descent

January 2011- June 2011

Measurements using the laser commode and proctography images were carried out by Gemma Faulkner

Inter-rater reliability measurements using the laser commode were carried out by Gemma Faulkner and Karen Rose (Research Registrar in Urogynaecology) at St Mary's Hospital, Manchester (25 patients were measured).

The relationship between perineal descent and joint hypermobility

January 2011-August 2011

Measurements using the Beighton score and proctogram images were carried out by Gemma Faulkner.

The relationship between perineal descent and other proctographic findings in patients with pelvic floor dysfunction

November 2010-August 2011

Measurements using proctogram images were carried out by Gemma Faulkner.

To test the reproducibility of the proctography measurement technique 50 proctograms were reviewed by Kandise Jackson (Registrar in Radiology) at the University Hospital of South Manchester.

All of the proctography examinations were carried out by Andrea Owen (Radiographer) at the University Hospital of South Manchester between July 2009 and July 2011.

The relationship between clinical symptoms and proctographic findings in patients with pelvic floor dysfunction

November 2010-August 2011

Measurements using proctogram images were carried out by Gemma Faulkner.

Questionnaires were distributed and processed by Gemma Faulkner.

Connective tissue changes in rectal prolapse

February 2011-August 2011

Biopsies were taken by Gemma Faulkner with help from Mr E Kiff, Miss K Telford, Miss S Duff (Consultant Colorectal Surgeons) and Miss T Onon (Consultant Obstetrician and Gynaecologist).

Tissue processing and staining was carried out by Gemma Faulkner and Catherine Keeling (Histopathology Research Technician) at Manchester Royal Infirmary, Manchester. The slides were examined and graded by Professor A Freemont at Manchester Royal Infirmary, Manchester.

Presentations and Abstracts

September 2012- 7th Scientific meeting of the European Society of Coloproctology, Vienna, Austria

Oral poster presentation: The relationship between clinical symptoms and proctographic findings in patients with pelvic floor dysfunction

September 2011- 6th Scientific meeting of the European Society of Coloproctology, Copenhagen, Denmark

Poster presentation: The relationship between perineal descent and joint mobility

Abstract: *Colorectal Disease vol 1 supp 6 September 2011*

August 2011- 41st annual meeting of the International Continence Society, Glasgow,

Oral poster presentations:

The laser commode: A novel device for the measurement of perineal descent

A retrospective review of proctographic findings in patients with pelvic floor dysfunction

April 2011- Northern functional bowel meeting, Manchester, UK

Oral presentation: Proctographic findings in pelvic floor dysfunction

Abbreviations

PD	Perineal Descent
PNTML	Pudendal Nerve Terminal Motor Latency
RI	Rectal Intussusception
BJHS	Benign Joint Hypermobility Syndrome
PFDI	Pelvic Floor Distress Inventory
H+E	Haemotoxylin and eosin
EVG	Elastic Van Gieson
EMG	Electromyography
SNS	Sacral Nerve Stimulation

Chapter 1. Introduction

1.1 The anatomy of the pelvic floor

1.1.1 The pelvic floor muscles

In 1543 Vesalius described the pelvic floor as a diaphragm comprised of a group of muscles.[1] The bilateral levator ani muscles attach to the internal aspect of the bony pelvis and form the bulk of the pelvic floor diaphragm. Their medial borders are separated by the outlets of the vagina, urethra and rectum. Contraction of these fibres compresses the visceral outlets and counteracts intra-abdominal pressure. The levator ani are divided, on anatomical grounds, into several parts; pubococcygeus, iliococcygeus and ischiococcygeus although they function as a single unit.

Pubococcygeus arises from the pubis anteriorly and passes backwards to attach to the musculotendinous anococcygeal ligament which lies between the anus and the coccyx and, with the overlying presacral fascia, provides a platform for the distal rectum. Medial fibres from pubococcygeus contribute anteriorly to the sphincter urethrovaginalis (and levator prostatae in the male) and pubovaginalis which surround the vagina and inserts into the perineal body. Iliococcygeus, arising from the obturator fascia, and ischiococcygeus, arising from the tips of the ischial spines, form the most posterior part of the pelvic floor. They attach to the anococcygeal ligament, the coccyx and the 5th part of the sacrum. The band-like puborectalis on each side passes below the main pubococcygeus muscle to join with and reinforce the external anal sphincter and to form a sling posteriorly around the rectum at the anorectal junction. This pulls the rectum

towards the pubis creating the anorectal angle.[2] A study by Lien (2005) using a computer simulated model of vaginal childbirth suggested that it is pubococcygeus that is subjected to the most strain during delivery.[3]

In 1962 Parks used concentric needle electromyography to demonstrate the constant activity of the pelvic floor muscles.[4] This is maintained by a spinal reflex. Ashton-Miller's (2007) review of the functional anatomy of the pelvic floor suggests that this constant contraction of the levator ani may act to reduce the transfer of damaging intra-abdominal forces to the connective tissues of the pelvic floor.[5]

1.1.2 The perineum

The textbook definition of the perineum refers to the trapezoidal region below the pelvic floor diaphragm. It is bounded anteriorly by the pubic arch, posteriorly by the coccyx and on each side by the inferior pubic and ischial rami and the ischial tuberosities. Superficially it is covered by skin and extends laterally to the buttocks and the medial sides of the thighs. Clinically the term perineum refers to the area between the anus and the vagina or base of the scrotum. This region encompasses the perineal body and its overlying skin. A transverse line drawn in front of the ischial tuberosities divides the perineum into an anterior urogenital triangle and a posterior anal triangle.[2]

1.1.3 The posterior anal triangle of the perineum

The contents of the posterior triangle are similar in both sexes. The anal canal is four centimetres long in the adult; it begins at the anorectal junction where the rectum narrows and passes downwards and backwards. It consists of a muscular tube formed by the inner internal and outer external anal sphincters. The internal anal sphincter is a continuation of the smooth muscle of the rectum, it encircles the upper three centimetres of the anal canal and it is under intrinsic autonomic control.[2] The sympathetic innervation maintains constant tonic contraction of the muscle to keep the anal canal sealed.[6] The preganglionic efferent sympathetic fibres originate in the thorocolumbar ganglia and are conveyed via the inferior hypogastric plexus. The parasympathetic supply is derived from the pelvic splanchnic nerves of the S2, 3 and 4 roots.[2] Parasympathetic discharge relaxes the internal anal sphincter and increases the intensity of colonic peristalsis.[7]

The external anal sphincter is comprised of skeletal muscle which is under conscious control and can be voluntarily contracted to prevent defaecation. Classically it was described by Milligan and Morgan (1937) as having three parts; superficial, subcutaneous and deep.[8] This theory has since been contested by Goligher (1955) [9] and Ayoub (1979) [10] who could not identify these layers in cadaveric and operative specimens. In women the external sphincter is shorter anteriorly and this can be demonstrated using endoanal ultrasound imaging.[11] Type I (slow twitch) muscle fibres are predominantly found in the external sphincter, they are slow to fatigue and

thus help to maintain a persistent tonic contraction of the external sphincter which aids the internal sphincter in maintaining closure of the anal canal.[12]

The longitudinal muscle is a continuation of the rectal smooth muscle which lies between the two sphincter muscles. The exact function of this muscle is unknown but it is likely to provide support to the sphincter complex and to facilitate defaecation by eversion of the anus.[13]

Above the dentate line the anal canal is lined by columnar epithelium and below it there is stratified squamous epithelium.[14] The mucosa of the anal canal is thick and folded into four to six highly vascularised cushions. Engorgement of these cushions manifests clinically as haemorrhoids.[15]

The ischiorectal fossae are the wedge-shaped spaces on either side of the external anal sphincter muscle. The wide base lies on the perineal skin and the tapered end lies between the obturator internus muscle and the levator ani. They contain fatty tissue and are traversed by the inferior rectal vessels and nerves. In the lateral wall the internal pudendal vessels and the pudendal nerve are encased in the fascial tunnel of the pudendal canal.[2]

The pudendal nerve arises from the 2nd, 3rd and 4th sacral nerve roots. Direct branches from these nerve roots supply the levator ani muscles. The pudendal nerve leaves the pelvis through the greater sciatic foramen but re-enters it accompanying the internal

pudendal artery via the lesser sciatic foramen. The inferior rectal nerve is the first branch, it provides the motor innervation of the external anal sphincter and the afferent sensory innervation of the mucosa of the lower anal canal. The nerve terminates in the dorsal nerve of the penis/clitoris and the perineal nerve which supplies the sphincter urethrae and the skin of the labia or scrotum.[2]

1.1.4 The anterior urogenital triangle of the perineum

The anterior urogenital triangle contains superficial and deep perineal muscles separated by a fascial layer, the perineal membrane. The same muscles are present in both sexes but they differ in size and position in the female because of the addition of the vagina.

The deep layer is comprised of the sphincter urethrae/urethrovaginalis and the right and left deep transverse perinei muscles. In the superficial layer bulbospongiosus lies in the midline, it consists of two parts which are separated by the vagina. It attaches to the clitoris anteriorly and the perineal body behind. The smaller ischiocavernosus also forms an attachment to the crus of the clitoris. The right and left superficial transverse perinei form a thin strip of muscle which lies in a transverse position in front of the anus. The perineal body is an important structure within the perineum. The perineal muscles originate on the bony pelvis, they converge on this fibromuscular nodule and then attach around the urethra, anus and vagina or bulb of penis. They help to empty the urethra during urination and ejaculation in the male and to maintain penile and clitoral erection. They also play a vital role in enabling the perineal body to anchor the pelvic viscera.[2]

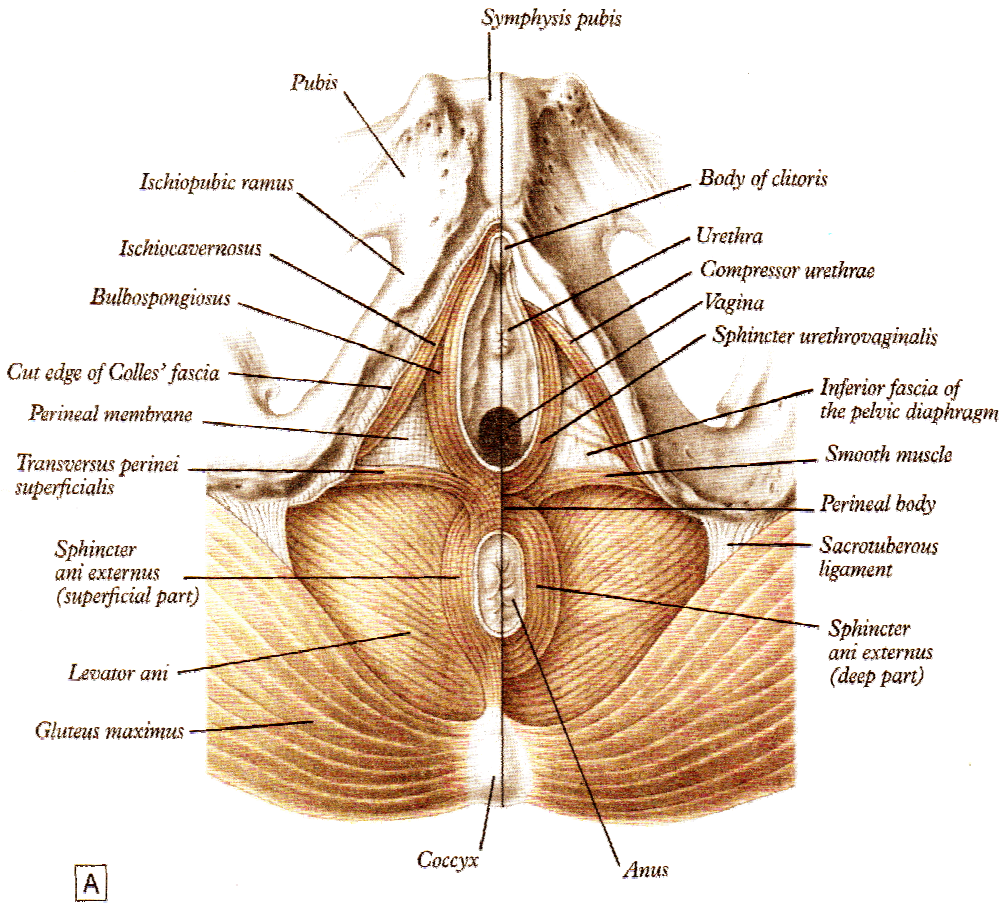


Figure 1. The muscles of the female perineum
(reproduced from Gray's Anatomy with kind permission from Elselvier)

1.1.5 The physiology of normal defaecation

The pelvic floor has two main roles; to support the pelvic organs and to aid the processes of defaecation and micturition.[16] The defaecatory process begins with an increase in intra-abdominal pressure generated by contraction of the rectus abdominis and levator ani muscles and descent of the diaphragm. In combination with the peristaltic action of the colon this moves the stool into the rectum which acts as a faecal conduit. Distension

of the rectum stimulates pelvic floor stretch receptors which trigger the conscious sensation of a "call to stool". Rectal distension also causes transient relaxation of the internal anal sphincter via the rectoanal inhibitory reflex.[17] This allows "sampling" of the rectal contents by the richly innervated mucosa of the upper anal canal. This process provides conscious awareness of the nature of the rectal contents (gas, liquid or formed stool).[18] If it is convenient for defaecation to occur a squatting or seated position is adopted and intra-abdominal pressure is increased again. Puborectalis relaxes causing the anorectal angle to widen. The external anal sphincter relaxes under voluntary control and the anal canal shortens and widens allowing eversion of the anus.[19] The perineum descends and the pelvic floor becomes funnel shaped assisting the passage of stool through the anal canal. Straining further widens the anorectal angle and relaxes the anal sphincters. At the end of defaecation there is a brief contraction of puborectalis and the external anal sphincter, this "closing reflex" aids the closing of the anal canal.[20]

1.1.6 Maintaining continence

The maintenance of continence requires the interaction of multiple factors. Ideally stool must be formed and firm in consistency as a liquid stool rapidly delivered into the rectum may overcome the sphincter mechanism. To function as a conduit for faeces the rectum must be able to distend adequately. Pathological conditions such as inflammatory bowel disease or radiation proctitis can lead to faecal incontinence by reducing rectal compliance.[21] Miller et al (1988) found that the anal sampling reflex was absent in some patients with faecal incontinence and in others a greater rectal volume was required to induce the reflex. Therefore abnormal anorectal sampling may

contribute to the development of incontinence.[18] The normal process of defaecation is disrupted if the rectoanal inhibitory reflex is absent, this is the case in Hirshsprungs disease [22] and after excison of the anorectal mucosa.

To maintain closure of the anal canal the pressure within it must exceed the intrarectal pressure. The normal mean resting pressure in females without anorectal disease is 56 to 74 mmHg (64 to 80 mmHg in healthy males).[23] Lestar et al (1989) measured maximal anal basal pressure in 21 healthy subjects (both with and without muscle relaxation) and found that 55% of the resting pressure is contributed by the internal sphincter, 30% is due to external sphincter activity and the haemorrhoidal plexuses are responsible for the remaining 15%.[24] Voluntary contraction of the external anal sphincter prevents defaecation when it is inconvenient. Maximum squeeze pressures of 175 to 211 mmHg and 124 to 162 mmHg can be achieved in normal males and females respectively.[23] Faecal incontinence may therefore develop when there is disruption of the sphincter ring caused by obstetric trauma or denervation of the muscle because of neurological injury.

To allow evacuation the external anal sphincter must relax along with the other striated muscles of the pelvic floor. Widening of the anorectal angle is achieved by relaxation of puborectalis. Uncoordinated relaxation of these muscles with paradoxical contraction of puborectalis or the external sphincter is seen in the functional disorder, anismus, and is a recognised cause of obstructed defaecation.[25]

1.2 The composition of connective tissues

Connective tissues are the support cells which provide scaffolding for the body. Muscle, bone, ligaments and tendons belong to this category along with any other tissue which provides organ support. Stability is maintained by a balance of cell synthesis by fibroblasts and breakdown by proteinases.

Connective tissues consist of reticular, elastic and collagen fibres surrounded by a ground substance of proteoglycans and glycosaminoglycans. Collagen is the most abundant component. It provides support, resistance to force and tensile strength. The triple helical structure of collagen was first proposed in 1954.[26] The molecule consists of three helical chains of amino acid residues (α-polypeptide chains) which are twisted into a triple helix and stabilised by hydrogen bonds. Every third amino acid residue is glycine. The α-polypeptide chains vary according to the type of collagen. Under polarised light collagen fibres can be seen to possess a pattern of alternating light and dark bands, this is formed by crimping of the fibre at an angle of 5 to 25 degrees. This crimp pattern provides the "shock absorber" system of collagen.[27]

1.2.1 Collagen types

Roman numerals are assigned to the collagen types based on the chronology of their discovery. Currently 29 types are recognised although the first five are most commonly known. They can be classified further into families according to the way in which the molecules assemble to form supporting structures (fibrous, network, filamentous and fibril-associated).[27] In fibrous collagen the molecules are aligned parallel to each

other in an overlapping arrangement designed for load-bearing. Examples of fibrous collagen include the major types I, II and III and the minor types V and IX.[27] Type I collagen is most prominent throughout the body being present in bone and tendon. Type II is found predominantly in cartilage while type III collagen is largely found in the vascular system and the skin. The network collagens form a mesh-like structure which is present in basement membranes and thus facilitates filtration e.g. in the glomeruli of the kidney nephron (type IV) and the cornea of the eye (type VIII). [27, 28]

In addition to the alignment of the fibres, the ratio of collagen types also reflects the function of the tissue. Minor collagen types are found in association with the major collagen types in most tissues. In the pelvic floor types I and III predominate with a contribution from type V.[29] The small, low strength fibres of type V collagen are found in smooth and skeletal muscle and in the placenta.[28, 29] Type III fibres also have a smaller diameter and provide a degree of elasticity, hence their importance in blood vessels, whereas the larger type I fibres confer greater mechanical strength.[29] During wound healing after injury disorganised bundles of flexible type III fibres are laid down initially but they are later replaced by well organised parallel type I fibres which confer a greater tensile strength to the scar.[30] Matrix metalloproteinases are the zinc-dependent enzymes responsible for degradation of collagen during tissue remodelling.[31]

The elastic fibre content of connective tissues provides extensibility, the fibres can double in length and still return to their original size.[32] They are comprised of

amorphous elastin, which is made up of amino acid residues, on a framework of microfibrils made of the protein, fibrillin. Elastic fibres are found in large blood vessels, some ligaments and in the skin and lungs.[32]

1.2.2 Measuring collagen

The identification of collagen within tissues is carried out using several methods. Histological stains are used to demonstrate collagen and elastin fibres which can then be viewed using light microscopy.[28] The quantity of collagen in the specimen is determined using computerised image analysis software or by using a semi-quantitative method in which a pathologist views the slides and estimates the percentage of stained collagen present. The commonly used special stains for collagen and elastin include Elastic Van Gieson, Masson's trichrome, Gomori's trichrome [33] and Verhoeff elastic.[33]

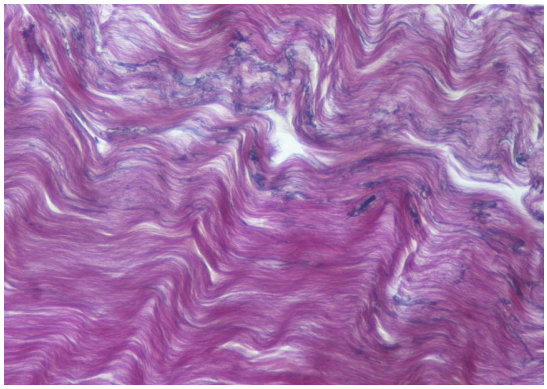


Figure 2. Rectus sheath stained with Elastic Van Gieson, collagen fibres stain pink-red, elastin stains dark blue (from Connective tissue changes in rectal prolapse, chapter 6)

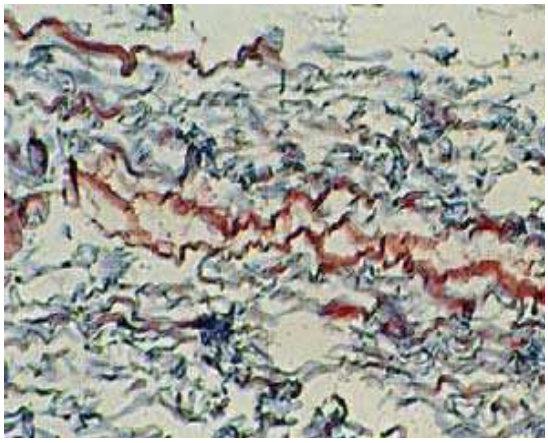


Figure 3. Bladder submucosa stained with Masson's trichrome, collagen stains blue and elastin stains red.[34]

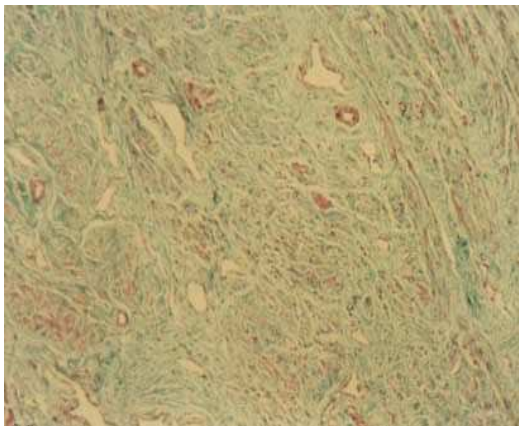


Figure 4. Vaginal fascia stained with Gomori's trichrome, collagen stains green.[33]

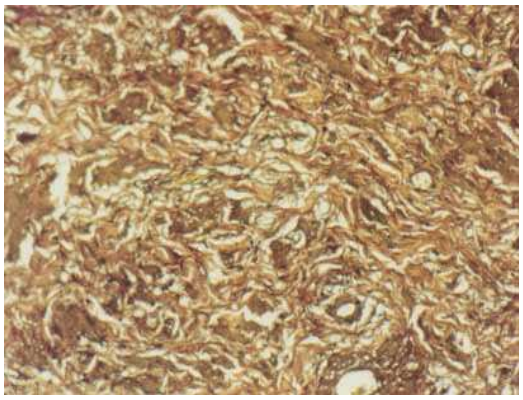


Figure 5. Vaginal fascia stained with Verhoeff''s elastic stain, elastin stains black.[33]

Table 1. Example of semi-quantitative pathology scoring system used to quantify connective tissue components after special staining [33]

Connective tissue components	Minimal	Moderate	High
Collagen	1	2	3
Elastin	1	2	3
Fibroblasts	1	2	3

Spectrophotometry may also be used to provide an assay of collagen when a tissue has been stained with the dye, sirius red.[35]

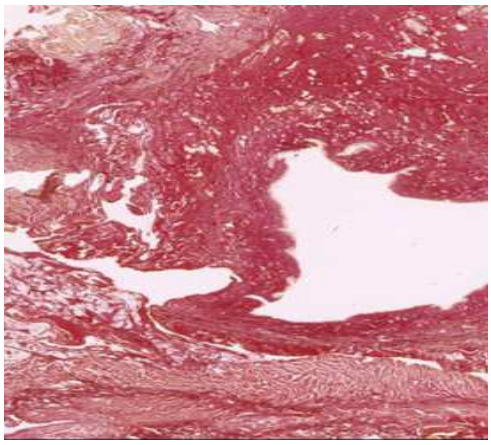
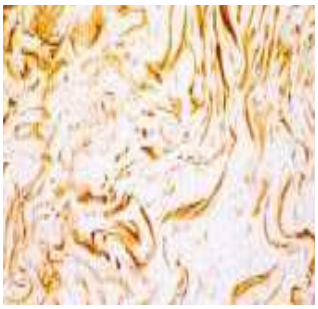


Figure 6. External urethral sphincter and levator ani muscle stained with sirius red, collagen stains dark red. [36]

A hydroxyproline assay may also be used to determine the total amount of collagen in a tissue sample. The amino acid, hydroxyproline is a major component of the collagen molecule (approximately 10%). [37] Hydroxylation of proline requires vitamin C, without it the collagen molecule looses stability and the effects of scurvy are seen.[31] Hydrolysis of a biopsy specimen with an acid solution produces hydrosylates which can then be analysed for the presence of hydroxyproline. The amount of hydroxyproline needs to be multiplied by a consistent number to provide an estimate of total collagen content.[38]

Collagen is an insoluble protein, it can be extracted from other proteins by using pepsin to digest the tissue. Individual collagen types can be distinguished due to the different salt concentrations required for them to precipitate.[39] Currently immunohistochemistry techniques are most often employed to isolate specific collagen types. Monoclonal antibodies are used to detect antigens present on collagen types I to V and the intensity of the immunohistochemical stain can again be estimated by a pathologist or quantified using image analysis software. [40-42]

7.  **8.** 

Figures 7 and 8. Immunohistochemical staining of cardinal ligaments showing collagen type I (7) and collagen type III (8) [42]

1.2.3 Collagen and connective tissue diseases

Ten variants of Ehlers-Danlos syndrome have been described but the genetic basis has not been elucidated for all of the types.[43] Most are thought to be due to genetic defects affecting collagen types I, III and V. Individuals with type I Ehlers-Danlos syndrome have hypermobile joints and thin, abnormally extensible skin. A null allele for the gene COL5A1 or COL5A2, inherited in an autosomal dominant fashion, is responsible for 30% of cases of Ehlers-Danlos type I.[44] Structural defects in the α-polypeptide chains of collagen type III encoded by the COL3A1 gene are responsible for

the vascular Ehlers-Danlos (type IV) which is associated with spontaneous rupture of the arteries, uterus and bowel.[44]

Marfan's syndrome is dominantly inherited and characterised by tall stature and hypermobile joints.[43] It occurs because of mutations of the gene (chromosome 15q21) that encodes for fibrillin-1, a major component of elastic fibres.[45] The distribution of fibrillin-1 throughout the major blood vessels and the eye explains the propensity to dilatation and dissection of the aorta and subluxation of the lens of the eye.[45]

1.2.4 Collagen and Ageing

Intermolecular cross linking of collagen molecules occurs with age and produces tissue changes which result in skin wrinkling, joint stiffening, rigidity of tendons and bone and alterations in the filtration properties of the kidney and the elasticity of the vascular system.[27] In mature collagen structures fibrils with a large diameter and hence, greater tensile strength, are uniformly distributed or interspersed with some collagen types with smaller fibril diameter to add flexibility. With biological ageing the fibril diameter reduces in size and there is more likely to be a bimodal distribution of both large and small diameter fibrils which reduces the overall tissue strength.[46] The waveform angle of the collagen crimp pattern also increases with ageing. This reduces the "shock absorber" properties of the collagen molecule.[27]

The most important age-related change of collagen is cross linking. It involves two distinct mechanisms. The first is an enzymatic reaction that occurs during development

of the immature collagen. The molecules are connected by divalent cross links which are then altered to more stable trivalent links forming a strong network of collagen fibres. The presence of a large proportion of divalent links reflects the immaturity of the collagen.[47] This is a normal part of the maturation of collagen and it utilises the enzyme, lysyl oxidase.[32]

The second reaction takes place following collagen maturation and is the major cause of tissue deterioration with age.[32] Glucose is added to the collagen molecules ("glycation") in a random, non-enzymatic process. This is accelerated in diabetic subjects due to the high levels of circulating glucose. Glycation occurs by chance and the long biological half life of mature collagen makes it susceptible to this process. The products of this reaction, advanced glycation end products, form further intermolecular cross links which reduce the ability of the collagen molecules to form organised aggregates and affect their interaction with other cells.[32] This leads to a reduction in the flexibility of the tissue and increases resistance to enzymatic breakdown leaving "over mature" collagen which is brittle and more susceptible to damage.[29]

1.2.5 The connective tissues of the pelvic floor

A network of connective tissue structures above the muscular pelvic floor provides an additional suspensory system for the pelvic organs. DeLancey (1992, 1999) studied cadaveric pelves and surgical specimens to describe three levels of support for the vagina which are relevant to the development of pelvic organ prolapse.[48, 49] The endopelvic fascia surrounds the vagina and the condensation of this tissue posteriorly

forms the rectovaginal septum. Superiorly the fascia merges with the vertical fibres of the cardinal and uterosacral ligament complex attaching the upper vagina to the pelvic walls (level I). The fascia of the middle third of the vagina fuses laterally with the bilateral aponeurotic arcus tendineus fasciae pelvis which in turn attach to the bony pelvis (level II) and the fascia surrounding the lower vagina attaches to the perineal body and levator ani muscles (level III).

Historically clinicians and anatomists disagreed about the existence of a rectovaginal septum because cadaveric studies could not always demonstrate the distinct layer described by Gynaecologists. Milley (1969) conducted a study of human fetal and adult tissues and concluded that the rectovaginal septum was the equivalent of the rectovesical or Denonvilliers fascia in men, it is likely to vary in consistency with age and parity.[50] Richardson (1993) described the rectovaginal septum as a layer of dense collagen, elastin and smooth muscle cells which is subject to specific fascial defects which may allow the herniation of the anterior rectum into the vagina forming a rectocele.[51]

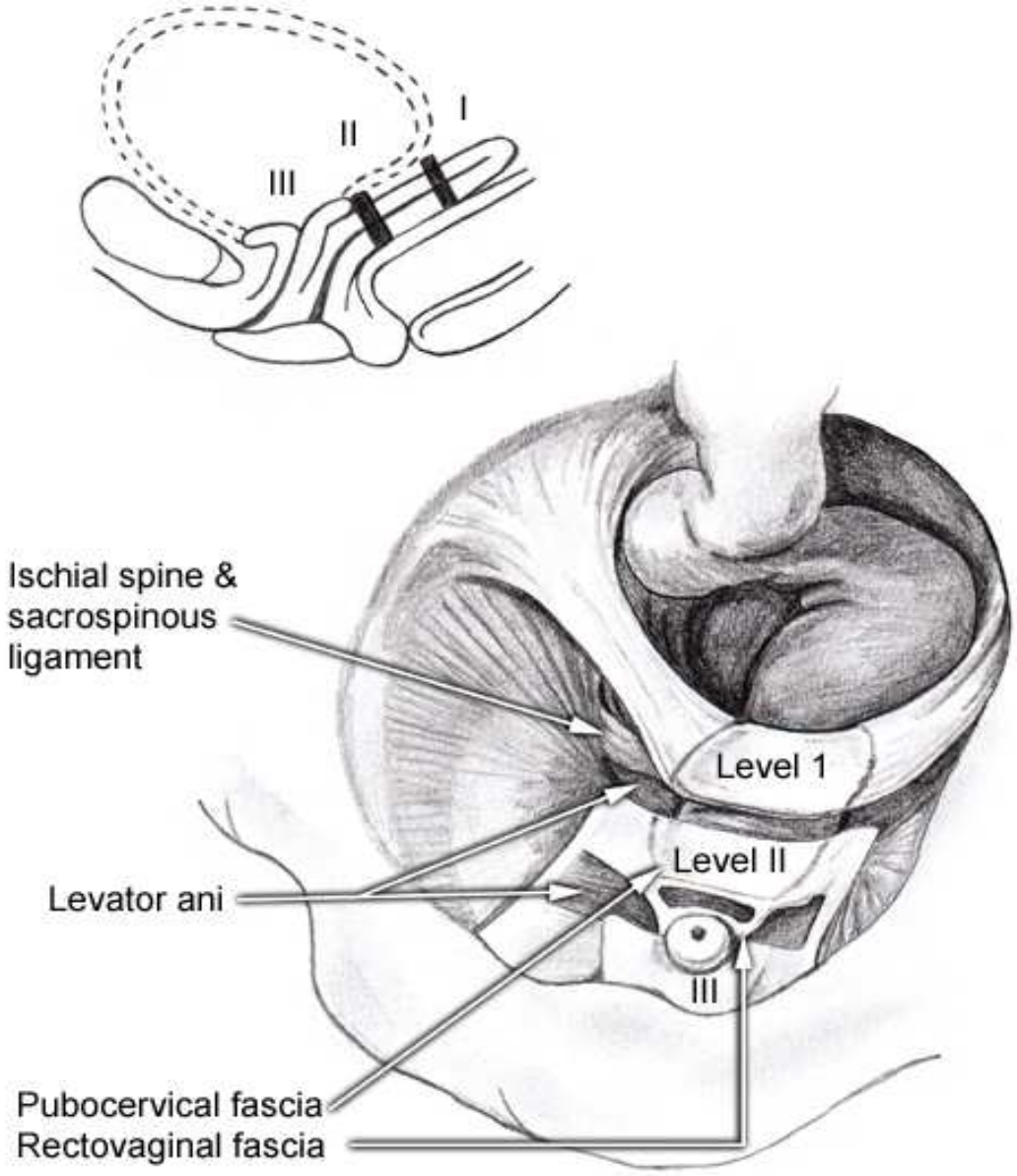


Figure 9. The three levels of connective tissue support for the vagina.[48]

1.3 Perineal Descent (PD)

Perineal descent is the abnormal ballooning of the perineum below the bony outlet of the pelvis. It is seen at rest or during straining to evacuate the rectum [52] and it is now considered to be a physical sign of connective tissue weakness. It is a common finding in patients who present with pelvic floor dysfunction and up to 75% of patients with faecal incontinence will have perineal descent on examination.[53]

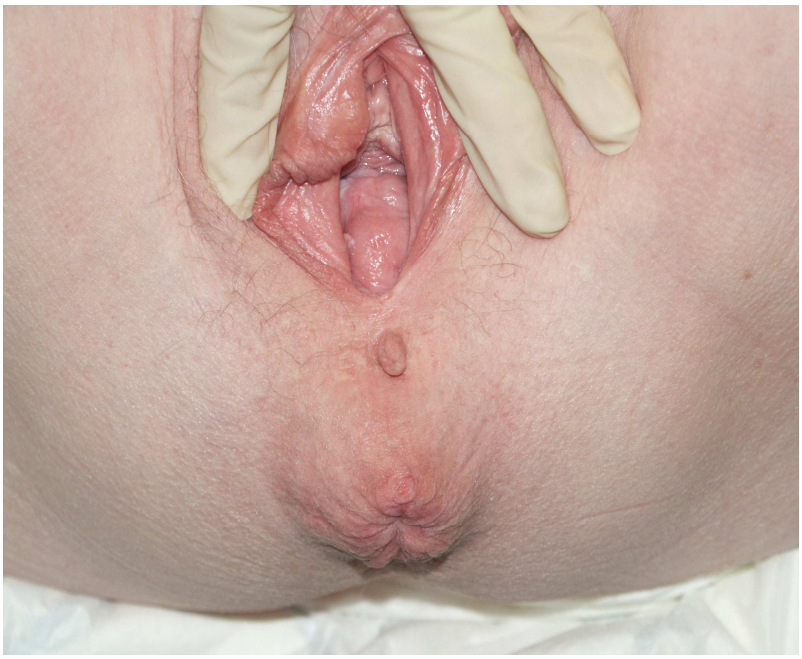


Figure 10. Perineal descent on clinical examination

Parks first described it in 1966 as the manifestation of a clinical condition - The Syndrome of the Descending Perineum.[52] The causative factor was thought to be excessive straining which over time led to permanent stretching of the pelvic floor

tissues and descent of the perineum. Other symptoms associated with the "syndrome" included perineal pain, tenesmus and the passage of blood and mucus per rectum. Parks noted that the anal margin should normally lie just below a line drawn between the symphysis pubis and the coccyx.[52] In patients with PD the anal margin lies several centimetres below this. Hardcastle and Parks [54] demonstrated this finding in 1970 using lateral pelvis X rays with the rectum outlined by a barium-soaked sponge. This method was also used to estimate the angle between the anal canal and rectum. Parks emphasised the importance of the anorectal angle in maintaining continence. As intra-abdominal pressure increases the anterior rectal wall is compressed towards the upper anal canal. This acts as a flap-valve and prevents defaecation.[52] The anorectal angle becomes more obtuse when there is descent of the perineum. Parks concluded that the combination of rectal mucosal prolapse and disruption of the flap-valve mechanism was the cause of faecal incontinence in patients with PD. Management was therefore aimed at re-creating the anorectal angle with a postanal repair with or without rectopexy to correct the prolapse.[55] At this time surgical options for the treatment of idiopathic faecal incontinence were limited but the long term results of this anatomy-restoring operation were disappointing [56-60] and although postanal repair may still have a part to play in the management of incontinence other operations are now more commonly undertaken.

In the 1980s the view that PD was part of a syndrome began to change. Faecal incontinence in a patient without anal sphincter disruption to account for it was labeled "idiopathic". Kiff (1984) used transrectal pudendal nerve terminal motor latency

(PNTML) measurements to demonstrate a delay in conduction in the distal part of the pudendal nerve in patients with idiopathic faecal incontinence. This supported the theory of a neurogenic basis for this condition.[61] The nerve entrapment hypothesis posed a possible explanation for the link between PD and faecal incontinence. Henry (1982) found that external anal sphincter biopsies from patients with PD showed evidence of muscle fibre hypertrophy. This is a compensatory change seen when partial denervation of the muscle has occurred.[62] An abnormal two centimetre descent of the perineum can stretch the pudendal nerve by 20% causing a neuropathy which may lead to sphincter muscle weakness and therefore to faecal incontinence.[62] Several studies concur with the nerve entrapment theory and show a correlation between the presence of PD and pudendal neuropathy [63-65]. They all used PNTML measurement and a simple mechanical means of measuring PD – the St Mark's perineometer. Jorge et al (1993) used a different method of descent measurement (defaecating proctography) in their study of 213 patients. They did not find a significant correlation between PD and prolonged PNTML.[66]

The role of PD as a causative factor in idiopathic faecal incontinence has been disputed because this sign is not always seen in association with the condition. Snooks (1985) explored the innervation of the puborectalis and external anal sphincter muscles in groups of patients with idiopathic faecal incontinence alone and in combination with rectal prolapse. Ten of the twelve patients with prolapse had evidence of PD but in the group of 20 patients with incontinence but no prolapse eight did not have any demonstrable PD.[67] Long standing constipation is not consistently associated with

PD.[68, 69] Harewood et al (1999) reviewed the proctograms of 39 patients presenting over a decade, they noted the correlation between the presence of PD and a history of excessive straining but 22% of the patients with disorders of evacuation did not have radiological evidence of PD.[70]

Although as previously stated PD is a common finding in patients with pelvic floor disorders, [53] we do not know exactly how it relates to clinical symptoms. Broekhius (2010) assessed a group of women with urogynaecological prolapse. PD was diagnosed using supine magnetic resonance imaging. Patients found to have PD did not report an increased incidence of faecal or urinary incontinence although there was a positive correlation between the degree of PD and prolapse symptoms.[71]

1.3.1 Measurement of perineal descent

Mechanical method

The St Mark's perineometer is a simple device created by Henry in 1982.[62] It comprises a graduated latex cylinder which moves freely within a steel frame. The two vertical limbs of the frame are placed against the ischial tuberosities with the patient lying in the left lateral position. The central cylinder is placed against the perineal skin and movement of the perineum in relation to the ischial tuberosities is recorded using a centimetre scale on the central cylinder.

Figure 11. St Mark's perineometer

Henry measured PD in a group of 103 asymptomatic control subjects.[62] The perineum was found to lie a mean of 2.5cm above the tuberosities at rest and 0.9cm above during a straining effort. In 20 patients with clinical evidence of PD the perineum was found to be 2cm above the tuberosities at rest but it descended to 1.2cm below the level of the tuberosities on straining.

The St Mark's perineometer is a safe and portable device. Importantly it does not involve radiation. There are however, some drawbacks associated with this mode of measurement. Oettle et al (1985) showed that the perineometer underestimated pelvic

floor movement by up to 60%.[72] This study included 21 patients (16 had a diagnosis of irritable bowel syndrome and 5 were patients attending the surgical outpatient clinic), PD was measured using the perineometer and proctography. Movement of the pelvic floor, as represented by the anorectal angle, in relation to the pubococcygeal line was measured using the proctogram images. Abnormal descent was defined as movement greater than 3cm. The mean radiological measurement was 2.9cm compared to 1.2cm measured using the perineometer. The perineometer device is used with the patient lying on the left side which is not the physiological position adopted for defaecation and it may be difficult to apply the findings in this position to the clinical situation. The thickness of the subcutaneous tissue overlying the ischial spines and the degree of pressure applied to the perineometer frame by the operator may also affect the accuracy of measurements.[72]

Radiological

Presently the "gold standard" method for measuring PD is defaecating proctography [72]. As previously mentioned Parks and Hardcastle were able to gain some information from plain lateral x rays of the pelvis.[54] The anal canal and rectum were outlined using a barium-soaked sponge. A line was drawn between the pubic bone and the tip of the coccyx, this is the pubococcygeal line and it correlates with the position of the levator ani muscles. The anorectal angle is the axis between the anal canal and the distal posterior rectal wall. Radiographs were taken at rest and during contraction of the pelvic floor, a line was drawn between the anorectal angle and the pubococcygeal line and the increase in this distance on contraction corresponds to descent of the perineum.

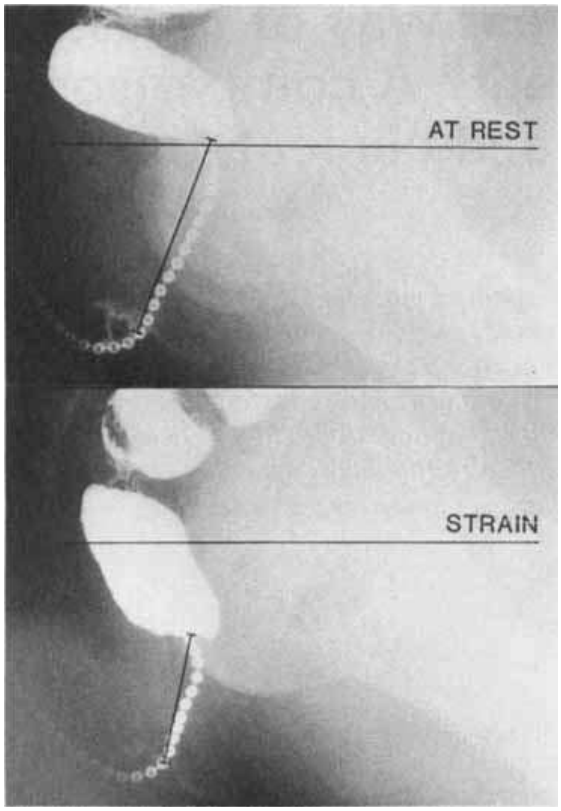


Figure 12. Perineal descent measurement using pubococcygeal reference line on proctography images.[72]

Wallden first described a dynamic means of visualising the phases of defaecation in 1952 during his study of the deep rectovaginal pouch.[73] Following this Burhenne published an intestinal evacuation study in 1964.[74] The technique was used as a research tool in the assessment of conditions such as rectal prolapse [75] but it did not find favour as a clinical investigation until the 1980s.[76-78]

A barium paste of stool consistency (150ml of barium diluted in 400ml of water) is injected via a catheter into the rectum; the injection is continued on withdrawal to outline the anal canal. A barium-soaked gauze swab can be placed in the vagina and the bladder may be outlined with contrast medium in order to assess movement in the

anterior compartments of the pelvic floor. The patient is positioned on a modified commode seat which is placed on the foot rest of a tilting radiography examination table. The patient voids the barium paste into a radiolucent receptacle while lateral views are recorded with the aid of fluroscopy using a video camera.[76, 77] The cinedefaecography examination will show the normal stages of defaecation including widening of the anorectal angle, relaxation of the puborectalis sling, opening of the anal canal and evacuation.[76] The technique is now used routinely to aid the diagnosis of pelvic floor disorders such as rectal prolapse and intussusception, rectocele, enterocele and anismus.

The radiological reference points used when measuring PD with proctography vary widely and this is one disadvantage of its use. The most commonly used method continues to be the vertical distance between the anorectal angle and the pubococcygeal line. A measurement greater than three centimetres is considered abnormal.[66] By including the bony landmarks of the pubis and sacrum the image field needs to be relatively wide, this can increase radiographic glare in the lower half of the image and this may adversely affect quality. Movement of the anorectal angle in relation to fixed landmarks other than the pubococcygeal line can be used to avoid this problem, examples include the ischial tuberosities [79] and the top of the commode seat.[80]

The anorectal angle can be measured in two different ways; by either using the angle formed by the longitudinal axis of the anal canal and a line drawn parallel to the distal half of the posterior wall of the rectum or the longitudinal axis of both the anal canal and

the rectum. Felt-Bersma (1990) found that the former method gave a more acute anorectal angle.[81] The puborectalis sling indents the rectal wall posteriorly to create the anorectal angle therefore using this method may seem more suitable.[76, 82] Choi's (2000) study of 135 patients using five observers found both methods to be a reliable way to measure PD but there were statistical differences between the two sets of measurements so it was concluded that a single centre should consistently use the same method.[83] The anorectal angle is at the proximal end of the anal canal. The anal verge is at the distal end and it is movement at this area that is measured by the perineometer. During normal defaecation the anal canal shortens as the pelvic floor descends, this means there is greater movement at the level of the anorectal angle than at the anal verge. This may contribute to the underestimation of descent when the perineometer is used.[72]

Although proctography is carried out in the physiological sitting position it is possible that the effect of gravity exaggerates findings especially if the patient is incontinent.[84] The fact that some patients may find this intimate examination to be unpleasant is also a significant disadvantage.

Jorge et al reviewed the clinical applications of cinedefaecography in 2001.[84] They commented on the wide range of normal values for the parameters commonly measured using proctograms- anorectal angle, PD and puborectalis length. This is due to variation in technique. They concluded that the change in measurements at rest and on straining in individual patients was more useful than comparison of absolute values to 'normal'

controls. In some patients, especially the elderly, there is significant PD at rest but no increase in descent on straining ("fixed increased perineal descent").[84] This may represent a permanently stretched pelvic floor with no residual elasticity.

It is difficult to define the appearances of a "normal" proctogram. Most defaecography studies have included only small numbers of asymptomatic controls because of the ethical issues involved with irradiating the normal pelvis. In some cases a control series has been extrapolated by selecting out normal studies of symptomatic patients.[85] Shorvon provided the only study of defaecography in normal subjects in 1989.[86] Findings that were previously considered to be pathological such as rectocele were demonstrated in the 47 asymptomatic volunteers. Intra- rectal intussusception was seen in 50% of the recruits (10 of the 20 nulliparous females and 12 of the 24 males). A rectocele was present in 17 females (81%) and in 10 cases was greater than 1cm in depth. It was a less frequent finding in the male volunteers (3 cases, 13%). [86]

In 1965 Devadhar first proposed the theory of rectal intussusception as the precursor for full rectal prolapse and a "reversed intussusception" surgical procedure to treat this finding.[87] This was supported by a dynamic cineradiography study by Broden and Snellman in 1968.[88] Later (Mellgren 1997, Choi 2001) follow-up defaecography studies of patients with recto-rectal intussusception failed to show progression to external rectal prolapse in significant numbers of patients although the follow-up periods where relatively short (one year and 45 months respectively).[89, 90]

Rectal intussusception is often noted during the proctography examinations of patients with both obstructed defaecation and faecal incontinence. The severity of the intussusception may be graded according to the position of the lowest extent of the prolapse. Shorvon (1989) used a seven stage description and later Wijffels (2009) introduced the Oxford radiological grading system comprised of four stages with a fifth to denote external rectal prolapse.[91]

Table 2. The Oxford radiological grading of rectal prolapse system [91]

Grade of Rectal Prolapse	Radiological Features
Intra-Rectal	
I	Descends to proximal limit of rectocele
II	Descends into level of rectocele
Intra-Anal	
III	Descends onto anal sphincter / anal canal
IV	Descends into anal sphincter / anal canal
Rectal Prolapse	
V	Protrudes from anus

Low grade intussusception is generally treated conservatively but opinion varies regarding the treatment of high grade intussusception (grades III and IV) with some centres favouring an operation designed to repair rectal prolapse. The advent of autonomic nerve-sparing surgery (laparoscopic ventral mesh rectopexy) has led to an increase in operative intervention for high grade rectal intussusception.[92] Pomerri (2001) [93] and Dvorkin (2005) [94] sought to explain the presence of rectal intussusception in asymptomatic individuals by suggesting that the thickness of the prolapsing rectal wall was greater in those with symptoms of obstructed defaecation. Returning to the theory of the natural progression of intussusception the large Oxford

study (Wijffels, 2009) found a positive association between increasing age and intussusception grade supporting the view that intussusception becomes prolapse with time.[91]

Like rectal intussusception the formation of a rectocele may be associated with symptoms of incomplete or obstructed defaecation and the need to digitate to aid evacuation.[95] Deficiency of the rectovaginal fascia allows the rectum to bulge forwards into the posterior wall of the vagina. Stool may enter the rectocele rather than the anal canal during defaecation giving the patient the sensation of a bulge anteriorly which is difficult to evacuate without straining, vaginal digitation and frequent return visits to the toilet. Post-defaecatory soiling may also occur due to trapping of stool in the rectocele which can leak out following defaecation. Collinson et al (2008) found a high incidence of rectocele and rectal intussusception together in a study of patients with faecal incontinence (35 out of 40 patients with a rectocele also had intussusception).[96] This combination was less frequent (33%) in patients with obstructed defaecation in the study by Thompson in 2002.[97] An enterocele may cause external compression of the rectum and contribute to obstructed defaecation symptoms. Over half of the patients with an enterocele in Mellgren's study in 1994 also had intussusception and 38% had a concurrent rectal prolapse.[98] Weakening of the pelvic organ connective tissue supports may be an aetiology common to all of the above mentioned proctographic findings but the exact injuries which lead to the development of certain conditions or combinations of conditions remain unknown.

1.2.2 The history of pelvic floor physiology

A variety of clinical tests are now available to assess pelvic floor structure and function. They are used in conjunction with physical examination and history taking to identify contributing factors, to allow comparison before and after intervention and to predict the progression of symptoms. The development of anorectal physiology studies and imaging has contributed greatly to our current understanding of pelvic floor physiology and although these tests are not without limitation they are now used routinely to help select appropriate treatment options for patients.

Anorectal physiology studies usually include anal manometry, endoanal ultrasonography and an assessment of pudendal nerve function. Initially the latter was provided by PNTML measurement and although it continues to be used in many centres the results do not influence the choice of treatment for faecal incontinence and PNTML is not a reliable predictor of outcome after surgical intervention to repair sphincter injury.[99] The external anal sphincter (supplied by the pudendal nerve) is responsible for the voluntary squeeze pressure generated during anal manometry. Squeeze pressures should therefore be reduced in the presence of pudendal neuropathy; but PNTML has not been found to correlate consistently with anal manometry.[100-103] Bilateral neuropathy was associated with reduced squeeze pressures in a large series of 2067 patients (Hill 2002) with faecal incontinence, however only 11% of these patients were found to have bilateral neuropathy using PNTML.[104] The measurement represents the speed of conduction in the fastest motor nerve fibres supplying the anal sphincter muscle, if some of these fibres are intact the measurement may continue to be normal even in the

presence of neuropathy. [105] The technique is operator-dependent and relies on close approximation between the measuring probe and the pudendal nerve as it curves around the ischial spine to enter the pudendal canal. Single fibre electromyography (EMG) may give more relevant results because it measures the characteristics of the muscle action potential, it is however, more invasive and can be difficult to perform.[106]

Before the advent of endoanal ultrasonography defects in the anal sphincter complex were diagnosed by using EMG to distinguish between normal muscle and scar tissue. Extensive work using both single fibre and concentric needle EMG in the 1970s and 1980s played a vital role in delineating our current understanding of the normal neuromuscular activity of the anal canal. [107, 108] The EMG needle records the amplitude and duration of action potentials generated by a motor unit. In the resting state there is tonic activity in the muscle, this activity increases on coughing and decreases when the sphincter relaxes. Denervation injury can therefore be detected by EMG; when the muscle has been denervated there is an increase in the number of muscle fibres supplied by a single nerve (increased mean fibre density). This is due to denervated muscle becoming re-innervated by an adjacent nerve and this can be demonstrated in patients with faecal incontinence.[109, 110]

The use of endoanal ultrasonography was first reported by Law and Bartram in 1989 [111], it has superseded EMG in the assessment of sphincter defects mainly because it is better tolerated by patients and easier to perform. The specificity and sensitivity reaches 100% for the diagnosis of external sphincter defects and 100% and 96% respectively for

those of the internal sphincter.[112] Although EMG is now not routinely used to assess sphincter defects it still has a role to play in the demonstration of pelvic floor dyssynergia and the diagnosis of anismus.[113]

Three dimensional ultrasound imaging was first introduced in 1999. [114] The four distinct tissue layers of the anal canal, the subepithelium, internal sphincter, longitudinal muscle and external sphincter, can be demonstrated. In addition to clarifying our understanding of anal canal structure endoanal ultrasonography was also used to determine the different anatomy of the female external sphincter. Initially anterior sphincter defects were over diagnosed but we now know that the anterior external sphincter is shorter in women and only present in the mid to lower portion of the anal canal.[11, 115]

Imaging modalities such as ultrasonography and proctography provide a structural assessment of anatomy but this may not reflect the functional activity of the pelvic floor. Manometry was developed to investigate the function of the oesophageal sphincter, it was first used in the anorectum by Hill et al in 1960.[116] Anal manometry is performed using an air or water filled balloon or solid state micro transducer connected to a pressure transducer. The balloon catheter is inserted via the anus into the lower rectum and withdrawn (the pull through technique) so that the anal canal pressure can be recorded at one centimetre intervals in relation to either the rectal or atmospheric pressure.[117] The main parameters measured are mean resting and squeeze pressures but the technique is also used to detect the presence or absence of the recto-anal

inhibitory reflex and to measure the length of the "functional anal canal" that is, the high pressure zone.[118] The development of anal manometry was paramount in defining the functions of the internal and external sphincter muscles by determining their contribution to the resting and squeeze pressures of the anal canal.[24] In addition the use of ambulatory manometry has shown the variations of anal canal pressure throughout the day and the changes in activity related to "anal sampling".[119] Patients with faecal incontinence are expected to have lower mean resting and squeeze pressures but this is not always the case. In Felt-Bersma's study of 350 (178 incontinent) patients in 1990 28% of the incontinent group had normal manometry values.[120] McHugh et al (1987) studied a group of 143 incontinent patients and found resting and squeeze pressures within the normal range in 39% of females and 44% of males.[121] Preoperative manometry results do not correlate with the clinical outcome after anterior sphincter repair and therefore cannot predict which patients will have a good functional result. [120, 122]

1.2.3 Patient selection for treatment

Faecal incontinence

Traditionally the treatment of an external anal sphincter defect would involve either sphincter repair or creation of a neosphincter. Since the introduction of sacral neuromodulation in 1992 this approach has changed. The mechanism of action of sacral nerve stimulation (SNS) is unknown, the beneficial effect on faecal incontinence was discovered during a trial of its use in urinary dysfunction.[123] Initially sacral neuromodulation was used in cases of idiopathic faecal incontinence with reduced mean

squeeze pressures but intact sphincters but the work of Chan et al (2008) [124] has shown a benefit in patients who have an unrepaired sphincter defect which has led to a reduction in the number of sphincteroplasties performed and the more complex, higher morbidity neosphincter procedures are now rarely necessary. The main limitation of sacral neuromodulation is the financial cost but peripheral nerve evaluation test stimulation has a low morbidity risk and although sphincter repair is still offered in certain cases SNS has now become the first line treatment for faecal incontinence (after simple conservative measures). A clinical trial by Kamm et al (2010) found that 39 of 45 patients (87%) with chronic constipation improved following SNS treatment, with an increase in the frequency of evacuations from 2.3 to 6.6 times per week. Sacral neuromodulation is therefore likely to play a significant role in the treatment of chronic constipation in the future.[125]

Internal anal sphincter dysfunction, demonstrated by reduced mean resting pressures or a defect on ultrasound imaging, and associated with passive faecal leakage may be managed using sphincter bulking implants.[126] With the emergence of laparoscopic ventral mesh rectopexy in the last decade some institutions have focused on correcting high grade rectal intussusception, diagnosed radiologically, in order to improve the symptoms of faecal incontinence.[127]

Obstructed defaecation

Proctography, anal manometry and colonic transit studies are used in conjunction with clinical assessment to distinguish chronic constipation from obstructed or difficult defaecation. The main surgical approach to obstructed defaecation involves correction of anatomical "abnormalities" demonstrated using proctography. Laparoscopic ventral mesh rectopexy and stapled transanal resection of the rectum are used to treat rectal prolapse, rectal intussusception, rectocele, enterocele and perineal descent. Proctography provides a dynamic assessment of defaecatory function and, in combination with anorectal physiology studies, it is an important part of the investigation of the patient with pelvic floor dysfunction, however, we cannot presume that isolated anatomical defects (which have also been demonstrated in asymptomatic individuals) are the sole cause of the pelvic floor pathology.

Pelvic floor dysfunction arises because of a global insult to the muscles, nerves and connective tissues of the pelvic floor often in combination with psychological issues [128] therefore the "snap shot" provided by investigations such as proctography may not be reliable in explaining the underlying aetiology. Although the surgical correction of anatomical defects may have a role to play in the treatment of pelvic floor dysfunction it may not guarantee the resolution of all clinical symptoms.

1.3 Joint hypermobility

1.3.1 Introduction

In 1967 Kirk defined the Hypermobility Syndrome as a condition of articular laxity associated with other symptoms.[129] In addition to excessively mobile joints affected patients were prone to orthopaedic complications and congenital dislocation of the hip.[130] It is now clear that the syndrome is associated with conditions unrelated to the musculoskeletal system including a propensity to develop varicose veins, herniae, skin abnormalities and pelvic organ prolapse.[131] This would suggest that joint hypermobility is part of a more generalised connective tissue abnormality. The condition is now more commonly referred to as the Benign Joint Hypermobility Syndrome (BJHS).[131]

The mobility of a joint is determined by several factors. These include the shape of the bony articulating surfaces, the neuromuscular tone, collagen structure and differences in proprioception.[43] Poor knee joint proprioception has been demonstrated in female patients with BJHS.[132] This deficit in sensory feedback may allow the subject to adopt biomechanically unsound joint positions.[132] Physiotherapy which enhances proprioception may be used for symptom control and pain relief.

1.3.2 Epidemiology

An hypermobile joint has a range of movement above that of the norm. This can be difficult to establish as joint mobility varies according to age, gender and race.[133]

Joints on the dominant side of the body are less mobile than the non-dominant, less frequently used side [7, 8]. It is important to distinguish between the presence of excessively mobile joints in a 'normal' person and the less common BJHS with its associated co-morbidity. The prevalence of BJHS is unknown.

Asian and African groups have a wider range of joint movement than Caucasians. Harris et al (1949) studied the variation in extension of the thumb joints in a group of University staff and students comprising European, Indian and West African nationals. The Indian subjects were found to have a striking ability to extend both joints of the thumb in comparison to Africans and Europeans of the same age and sex.[134] Certain geographical locations have a particular predominance of joint laxity. A survey of 1774 Iraqi University students in 1981 found the prevalence of hypermobility to be 25.4% in males and 38.5% in females.[135] Hippocrates noted the unstable elbows of the Scythian people in the 4th Century BC. This "flabbiness and atony" limited their ability to fire bows and throw javelins, the Scythians lived in the region of the Caspian Sea.[43, 136]

Many studies have attempted to determine the prevalence of hypermobility. A degree of population bias is present in the studies that have selected patients referred to Orthopaedic or Rheumatology outpatient clinics but Carter and Wilkinson (1964) found that 7% of English school children had more than three hypermobile joints [130] and in 1981 Jessee et al examined 637 healthy adult American blood donors, 4.9% met the criteria for hypermobility.[137] Joint laxity is more common in younger age groups,

mobility decreases rapidly throughout childhood and continues to decrease during adult life.[133] Approximately 10-20% of the adult population have more than one hypermobile joint.[138] Females have a greater degree of joint laxity than males.[7, 9-11] This is prominent at menarche [139], during pregnancy and for several months post partum [140]. This is likely to be related to a hormonal contribution.

Joint hypermobility does convey an advantage in some activities; there is a higher prevalence amongst gymnasts, ballet dancers [141] and certain musicians.[142] Flexibility can be increased further by altering neuromuscular tone through training.[43]

1.3.3 Heritable connective tissue diseases

There is a degree of overlap between BJHS and the serious heritable connective tissue diseases. Unlike BJHS these conditions are associated with pathological sequelae. Hypermobility is a feature that is common to them all. There are ten variants of the Ehlers-Danlos Syndrome. Before BJHS was recognised as a separate entity it was considered to be Ehlers-Danlos Type III – the benign hypermobility type.[138] The categorisation of BJHS remains contentious. Grahame and Bird's 1999 survey of 319 Consultant members of the British Society of Rheumatologists found that 9% considered BJHS and Ehlers- Danlos Type III to be one and the same condition.[143] To add further difficulty to the diagnostic process the blue sclerae seen in Osteogenesis Imperfecta and the tall, thin habitus of Marfan's Syndrome are also seen in some patients with BJHS.[43]

1.3.4 Genetic basis

Unlike Ehlers- Danlos Syndrome, Marfan's and Osteogenesis Imperfecta, the genetic basis of BJHS is unknown. Work in this area may be limited by the benign (in terms of mortality) nature of this condition. The distribution of BJHS amongst families points towards an autosomal dominant pattern of inheritance.[144] The twin study carried out by Hakim et al in 2004 estimated that 70% of the joint hypermobility phenotype can be attributed to genetic factors.[145]

Genetic mutations resulting in type V collagen abnormalities are found in 30 to 50% of individuals with classic Ehlers-Danlos Syndrome, which would suggest other genes must be involved in the pathogenesis.[146] Tenascin-X is a large glycoprotein found in the extracellular matrix of connective tissue. In a study of 151 patients with Ehlers Danlos Syndrome (Schalkwijk 2001) five were found to have a complete tenascin-X deficiency. These patients predominantly had hypermobility with skin fragility and easy bruising.[146] It is therefore possible that a lack of tenascin-X contributes to the development of joint laxity in BJHS. Haploinsufficiency of tenascin-X has also been found in patients with BJHS.[147]

1.3.5 Diagnosis

The main aim of the assessment of patients with joint laxity is to identify those with a potentially life-threatening connective tissue disorder. A detailed family history is essential. Molecular genetic analysis can be performed to look for the fibrillin-1

mutations seen in Marfan's Syndrome. Skin biopsies are used to make the diagnosis of Osteogenesis Imperfecta and Ehlers-Danlos Syndrome where abnormalities of collagen types I and III /V are seen respectively. These laboratory investigations are used in conjunction with the criteria outlined in the Ghent (Marfan's) and Villefranche (Ehlers Danlos Syndrome) nosology.

The Beighton Scoring System consists of a series of manoeuvres designed to identify generalised hypermobility.[133] It was established in 1973 and is based on a similar system used by Carter and Wilkinson in 1964.[130] A score of four out of nine is considered to be suggestive of hypermobility.

Table 3. The Beighton scoring system [133]

	RIGHT	LEFT
1. Forward flexion of trunk with knees straight and palms on floor	1	
2. Hyperextension of elbow to ≥10°	1	1
3. Hyperextension of knee to ≥10°	1	1
4. Opposition of thumb to volar aspect of ipsilateral forearm	1	1
5. Passive dorsiflexion of metacarpophalangeal joint to ≥90°	1	1
Maximum Total	**9**	

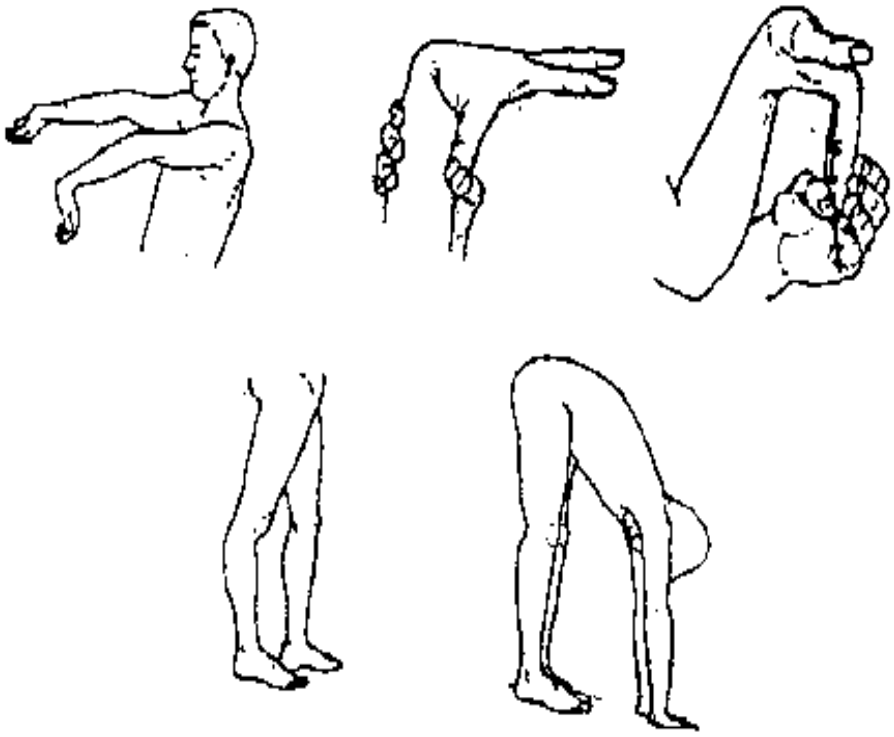


Figure 13. The Beighton score manoeuvres
(reproduced from Arthritis Research Campaign information booklet - Joint hypermobility)

Although this scoring system is quick and simple to perform it may miss hypermobility in some individuals as not all joints are assessed. It is not possible to diagnose the BJHS using the Beighton score alone. The Revised (Brighton 1998) Criteria [131] uses a Beighton score of 4 out of 9 in association with arthralgia and other symptoms to make the diagnosis. It is interesting to note that BJHS may be diagnosed when only a single lax joint is present.

Table 4. The 1998 Brighton revised diagnostic criteria for Benign Joint Hypermobility Syndrome [131]

Major Criteria
1. Beighton score ≥ 4/9 (currently or historically) 2. Arthralgia for > 3 months in ≥ 4 joints
Minor Criteria
1. Beighton score 1, 2 or 3/9 (0, 1, 2 or 3 if aged 50 + years) 2. Arthralgia (≥ 3 months) in 1-3 joints or back pain (≥ 3 months), spondylosis, spondylolysis or spondylolisthesis 3. Dislocation / subluxation in > 1 joint or in 1 joint on more than 1 occasion 4. Soft tissue rheumatism ≥ 3 lesions 5. Marfanoid habitus 6. Abnormal skin: striae, hyperextensibility, papyraceous scarring, thin skin 7. Eye signs: myopia, drooping eye lids or anti-mongoloid slant 8. Varicose veins or herniae or uterine **/ rectal prolapse**

The diagnosis of BJHS is made in the presence of two major criteria or one major and two minor criteria or four minor criteria. (Two minor criteria will be accepted if a first degree relative is affected).

Hakim and Grahame (2003) developed a screening questionnaire which can be used in a clinical setting to assess patients with musculoskeletal problems. One advantage of the questionnaire is that it will identify a past history of joint laxity which has resolved with age. If two or more responses are positive hypermobility is present with a sensitivity of 80-85% and a specificity of 80-90%.[148]

1. Can you now or could you ever place your hands flat on the floor without bending your knees?
2. Can you now or could you ever bend your thumb to touch your forearm?
3. As a child could you contort your body or could you do the splits?
4. As a child or teenager did your shoulder or kneecap dislocate on one or more occasion/
5. Do you consider yourself to be double-jointed?

Figure 14. Questionnaire to detect hypermobility [148]

1.3.6 Associated symptoms

The commonest presenting symptom in patients with BJHS is musculoskeletal pain.[138] Management comprises supportive, symptomatic care and reassurance. Affected individuals may become dissatisfied with medical professionals because of diagnostic delay but they may also have psychological problems unrelated to this.

Anxiety, fatigue and panic disorder are all seen in association with BJHS.[149] These features and other apparently non-specific symptoms such as fainting, shortness of breath, palpitations and gastrointestinal disturbance can be attributed to autonomic disturbance which is now known to occur with BJHS. Gazit et al (2003) found that 60% of BJHS patients experience these symptoms.[150] Small early studies found an increased incidence of mitral valve prolapse in patients with BJHS [151-153] however Mishra carried out an echocardiographic study in 1996 which found no significant increased incidence of mitral valve prolapse amongst the hypermobile subjects. The serious aortic complications seen in Marfan's syndrome were not found.[154] Mitral valve prolapse can give rise to symptoms of palpitation, shortness of breath and fainting which, as previously noted can occur in BJHS patients with autodysnomia.[149] Although there is no increased cardiovascular risk associated with BJHS one published study has shown an increased prevalence of asthma and lung collapse.[155]

Ehlers-Danlos Syndrome is associated with the risk of severe obstetric complications including antepartum haemorrhage, miscarriage and extensive perineal laceration.[156] These problems are not commonly seen in pregnant women with BJHS but they may experience premature rupture of the membranes and rapid, precipitous deliveries.[43]

A lack of local anaesthetic efficacy has been described anecdotally in patients with BJHS. The Danish group Arendt-Nielsen et al looked at eight Ehlers-Danlos Syndrome type III patients (as noted previously this condition is now deemed to be identical to BJHS). Topical anaesthesia did not provide cutaneous analgesia in the Ehlers-Danlos

Syndrome patients, infiltration of lignocaine did produce anaesthesia but the effect was short-lived compared to controls.[157] This is possibly due to increased vascular uptake of the anaesthetic solution or rapid dispersal in the abnormal cutaneous connective tissue. Some authorities have suggested the use of a local anaesthetic test or a questionnaire to identify previous local anaesthetic failures to help make the diagnosis of BJHS.[158]

The presence of varicose veins and herniae are included as minor criteria in the Brighton diagnostic system.[131] In the study of Iraqi University students varicose veins were seen more frequently in the hypermobile group especially in those subjects with the highest Beighton scores. [135]

1.4 Joint hypermobility and pelvic floor dysfunction

There is a small body of work which has examined the relationship between generalised joint hypermobility and the clinical problems associated with pelvic floor dysfunction. Urogenital prolapse is the most common indication for hysterectomy in women over the age of 50 years.[159] The degree of prolapse can be staged using the Pelvic Organ Prolapse-Quantification system.[160] Like joint hypermobility, the prevalence of pelvic organ prolapse varies according to ethnic background and age.[161] The large Women's Health Initiative Hormone Replacement Therapy Clinical trial found a degree of prolapse was present in approximately 40% of females.[161] The pathogenesis of prolapse is likely to be multifactorial. Contributing factors include pregnancy and vaginal delivery, ageing and the menopause and previous pelvic surgery [162] but up to

2% of young nulliparous women also have prolapse suggesting the presence of an underlying connective tissue deficiency.[163] Female patients with Marfan's syndrome and Ehlers-Danlos Syndrome have high rates of pelvic organ prolapse.[164]

Connective tissue changes have been identified in women with urogenital prolapse using both histology and immunohistochemistry techniques. In 1996 Jackson et al found a reduced amount of total collagen in the vaginal epithelial tissue of young women with pelvic organ prolapse.[38] This was associated with greater matrix metalloproteinase activity suggesting an increase in collagenolysis. Twelve studies of collagen analysis have been carried out since the year 1987.[33, 35, 38, 40-42, 165-170] A review article by Kerkhof (2009) summarised the findings of these studies.[29] The data are conflicting due to marked variation in biopsy site and analysis technique but Kerkhof concluded that they were supportive of the theory proposed by Jackson. The total elastin content was similar in patients with and without prolapse in the Jackson study but other groups have shown a reduction in elastin content in the tissues of women with pelvic organ prolapse.[42, 171] Jackson found a higher concentration of divalent collagen cross links and advanced glycation end-products in tissue from the prolapse group.[38] This suggests a propensity for immature easily degraded collagen and vulnerable "over mature" collagen in women with urogenital prolapse. Although Jackson found no difference in collagen type ratios, other work has shown an increase in type III collagen [33, 170] with or without a decrease in the stronger type I content.[169]

Al-Rawi was the first to report the connection between genital prolapse and joint hypermobility in 1982. The study included 76 female patients with genital prolapse and the same number of age and parity-matched controls. Joint mobility was assessed using the Beighton score. In the prolapse group 66% of patients were found to have hypermobile joints compared to 18% of the controls. The prolapse group also complained more frequently of joint pain. [172]

Using different criteria to grade hypermobility in 1995 Norton et al found that 39 of 108 consecutive women attending a gynaecology outpatient clinic had evidence of hypermobility. These patients were significantly more likely to report symptoms of urogenital prolapse.[173]

A single published study has shown a positive association between joint hypermobility and rectal prolapse. This included 25 patients who had undergone surgical repair of a complete rectal prolapse. Hypermobility was assessed by measuring maximum extension of the fifth finger only.[174] Beighton previously found a positive relationship between mobility score and flexibility of this particular joint.[133] It may therefore be possible to use this joint assessment alone to predict generalised hypermobility.[174]

In 2007 Jha et al recruited female patients with BJHS from Rheumatology outpatient clinics and used questionnaires to determine the prevalence of faecal and urinary incontinence. Both conditions occurred more commonly in the BJHS group (23% of

BJHS patients complained of faecal incontinence compared to none of the controls).[175] Arunkalaivanan confirmed these findings in a larger study of female members of the Hypermobility Syndrome Association in 2009.[176]

1.5 Aims of the study

1. A novel device for the measurement of perineal descent

The established mechanical method for PD measurement (the perineometer) is inaccurate compared to the gold standard of defaecating proctography. PD may be underestimated by the perineometer because of patient size and variations in operator technique. Proctography is currently considered to be the best method available to measure PD but the effect of gravity and the different anatomical sites used to represent the perineum may contribute to overestimation of descent.

The primary aim of this study was to develop a new mechanical device that could be used to measure PD in the other parts of this research work thus avoiding the use of radiation. The device comprises a modified commode and laser distance measurer. If found to be accurate and reproducible the mechanical device could be used both as a research tool during the other parts of this project and clinically in the future to assess pelvic floor movement.

2. The relationship between perineal descent and joint hypermobility

This study aims to determine whether PD can be a manifestation of a generalised connective tissue disorder rather than the consequence of childbirth trauma or straining to defaecate. A positive correlation between PD and joint hypermobility would support the theory that connective tissue abnormality contributes to the development of pelvic floor disorders. This finding may influence the choice of surgical intervention and help to predict the risk of recurrence after surgical repair in patients with PD and pelvic organ prolapse.

3. The relationship between perineal descent and other proctographic findings in patients with pelvic floor dysfunction

Stretching of the supporting tissues of the pelvic floor may lead to the formation of a rectocele, rectal prolapse or rectal intussusception. These are commonly reported findings on proctography examinations, they are thought to give rise to symptoms of difficult defaecation and faecal incontinence. Corrective surgery may be offered as a result. If PD is a sign of connective tissue weakness and if connective tissue weakness is common to all of these pelvic floor disorders it would be expected that patients with the greatest degree of descent also have other significant findings including rectal prolapse or high grade intussusception and large rectoceles. This study aims to determine the relationship between these proctographic findings in order to gain further knowledge about the pathophysiology involved in their development.

4. The relationship between clinical symptoms and proctographic findings in patients with pelvic floor dysfunction

Studies of proctography in normal volunteers are limited but PD, rectal intussusception and rectoceles have been found in "normal" asymptomatic individuals including nulliparous females and males. This study aims to determine the clinical relevance of these proctographic findings by analysing the results of symptom questionnaires (Pelvic Floor Distress Inventory short form 20) completed by patients with pelvic floor dysfunction who have been investigated with defaecating proctography.

5. Connective tissue changes in rectal prolapse

Studies have looked at the vaginal and parametrial tissue of women with urogenital prolapse and found a reduction in total collagen and elastin content, there has not been any similar work to assess the connective tissue composition of the pelvic floor in patients with rectal prolapse. The development of rectal prolapse is likely to be multifactorial and childbirth may be a major contributing factor. However, some patients present at a young age prior to pregnancy and in this group an underlying connective tissue abnormality may be the cause. The aim of this experiment is to compare connective tissue biopsies from several anatomical sites in patients with and without rectal prolapse.

In summary the aims of this project are;

1. **To assess the accuracy of a new mechanical device for PD measurement compared to the gold standard method, defaecating proctography**
2. **To determine whether there is a positive correlation between PD and joint hypermobility**
3. **To explore the relationship between PD and pelvic floor disorders diagnosed using defaecating proctography**
4. **To establish the relationship between clinical symptoms and pelvic floor disorders diagnosed using defaecating proctography**
5. **To compare connective tissue biopsies in patients with and without rectal prolapse**

Chapter 2. A novel device for the measurement of perineal descent

2.1 Aims

The purpose of this experiment was to determine the accuracy of a new mechanical device (the laser commode) for the measurement of PD. The new device and the established mechanical method, the St Mark's perineometer were compared to the current gold standard for PD measurement, defaecating proctography. Both of the currently used methods have disadvantages including underestimation of PD in the case of the perineometer and, radiation exposure. An accurate, acceptable and more physiological mechanical device could be used in research to measure PD and it could also be of use in a clinical setting especially in the assessment of antenatal patients.

2.2 Patients

Ethical approval was obtained from the Greater Manchester East Research Ethics Committee and written consent was taken from all participants. (REC Reference Number 10/H1013/80, January 2011).

PD measurements were performed by a single researcher in the Outpatient and Radiology departments. All participants in the study were patients with a pelvic floor disorder who were being treated at the Pelvic Floor Unit at the University Hospital of South Manchester. The range of clinical problems included; faecal incontinence, difficult or obstructed defaecation and rectal prolapse. Potential participants were identified using Outpatient and Radiology department records, they were contacted by

post and invited to return an “Expression of Interest” form. A positive reply was followed up by a telephone call to arrange to carry out the tests during an Outpatient clinic visit. The following data were recorded for each participant; age, gender, parity and nature of pelvic floor problem.

To establish the inter-rater reliability of the new device PD was measured a second time on the same occasion by a separate observer. This part of the study was carried out using a subgroup of female patients with pelvic organ prolapse. These patients were under regular follow-up at St Mary’s Hospital, Manchester where they attended for PD measurement as part of their participation in the PROSPECT trial, a national multicentre study of the surgical methods used to repair pelvic organ prolapse (PROlapse Surgery: Pragmatic Evaluation and randomized Controlled Trials, ISRCTN 60695184).

2.2.1 Inclusion criteria

Patients were included in the study if they had previously had a defaecating proctogram to investigate symptoms of faecal incontinence, difficult defaecation or pelvic organ prolapse.

2.2.2 Exclusion criteria

Patients were excluded if they did not require a defaecating proctogram to investigate their symptoms, if they were under the age of 18 years and if they had dementia or other cognitive problems which affected their ability to give informed consent to participate.

2.3 Materials and devices

2.3.1 Mechanical device 1 - perineometer

The perineometer consists of a metal frame with a central latex measuring cylinder which was held against the perineum with the patient lying on a couch in the left lateral position. The vertical limbs of the frame were adjusted to lie against the ischial spines. The centimetre scale on the cylinder shows the level of the perineum in relation to the ischial tuberosities. The measurement is positive if the perineum lies above this plane and negative if it lies below it. Disposable rubber sheaths were used to cover the limbs and measuring cylinder and the device was cleaned with alcohol after each use.

Figure 15. Perineometer

2.3.2 Mechanical device 2 – Laser commode

The new device is comprised of a commode and a digital laser distance measurer. The elliptical aperture of a conventional commode platform supports the perineum and can prevent descent therefore the platform has been modified to consist of two narrow wooden supports. They have been shaped with a medial ledge on each side.
The patient was seated so that the ischial tuberosities were positioned on the ledges and the perineum was not splinted by the supports. The supports were adjusted to correspond with the distance between the ischial spines. The platform surfaces were covered with disposable sheets during use and cleaned with alcohol afterwards.

The laser distance measurer (Bosch DLE 500) is a commercially available battery-operated device which can be purchased from hardware stores. It uses a class 2 laser which is safe for use on skin. It has a CE mark and is deemed acceptable for general use by the UK Health Protection Agency. It measures distances with an accuracy of ± 1.5 millimetres. The typical time taken for the device to complete a measurement is less than 0.5 seconds.

Figure 16. Commode platform

Figure 17. Digital laser distance measurer

Movement of the perineum was measured in relation to the level of the ischial tuberosities. This distance was calculated by placing a sheet of paper on the commode platform between the two ledges and measuring the vertical distance from the device on the floor to the paper. This level (46.2 centimetres) represents the plane of the ischial

tuberosities. Following calculation of this distance the commode height was not altered throughout the study.

Figure 18. Distance from laser distance measurer to level of ischial tuberosities

2.3.3 Radiological method - Defaecating proctography

Proctography has been carried out by the same Radiographer and Radiologist at the University Hospital of South Manchester since the year 2002. A consistent technique is employed. The images are stored electronically on computer software (Picture Archiving and Communications System, Centricity, GE Healthcare, UK).

To opacify the small intestine the patient is given 500 millilitres of oral barium contrast 30 minutes prior to the investigation. A barium paste of stool consistency (EZ-HD 98% w/w powder barium sulfate, Bracco UK Ltd, Bucks) is prepared. The patient lies in the left lateral position on a couch and a bladder syringe attached to plastic tubing with an enema tip is used to inject 60 millilitres of the paste into the rectum. A video seat containing a bedpan is fixed to the foot step of a tilting examination table. A bag of contrast is secured within the bedpan to absorb excess radiographic flare. The patient sits on the seat when the table has been tilted to the erect position. The lateral view of the rectum is positioned in the centre of the field. The video is commenced and the images are magnified using a standard fluoroscopy setting. The patient is asked to "lift" the pelvic floor, to strain down and then to evacuate the barium paste into the bedpan.

2.4 Methods

2.4.1 Perineal descent measurement – perineometer

The patients were positioned on an examination couch lying in the left lateral position with knees flexed and under clothes removed. The perineometer frame was adjusted so that the vertical limbs could be placed against the skin overlying the ischial tuberosities and the central cylinder rested against the perineum. A measurement was recorded at rest. The patient was then given a consistent verbal instruction to "bear down" and a further measurement was recorded (PD on straining). This was repeated three times to ensure the maximum possible descent had been captured.

2.4.2 Perineal descent measurement – laser commode

The patients were seated on the commode with the ischial tuberosities positioned on the ledges of the platform. The lower half of the body was covered with a sheet to prevent the risk of retinal exposure to the laser. The researcher adjusted the laser on the floor beneath the commode to direct the laser beam onto the perineum anterior to the anus in the 12 o'clock position. A measurement from the device to the perineum was taken at rest. The patient was then given the verbal instruction to "bear down" and hold this position and a further measurement was taken on straining. The researcher observed the perineum during the strain manoeuvre and activated the laser measurer when maximum descent was visualised. The process was repeated three times. The PD at rest was calculated by subtracting the distance from the laser device to the perineum at rest from the standard distance from the device to the level of the ischial tuberosities (this was measured previously as 46.2 centimetres). The PD on straining was calculated in the same way.

2.4.3 Perineal descent measurement – Defaecating proctography

The proctograms of the participants were reviewed retrospectively. During proctography the images are magnified using the fluoroscopy unit therefore a magnification factor was applied to all measurements. A phantom was used to calculate the magnification factor. A radio-opaque ruler marked with 1 millimetre increments was fixed within the bedpan and an image was recorded and stored on the Patient Archiving and Communication system. The phantom image was viewed on an RA 1000 computer monitor and compared

to the actual ruler. One centimetre on the ruler was equal to two centimetres on the phantom image therefore all measurements made on the proctograms were divided by two. The same RA 1000 computer monitor was used to view all of the proctograms.

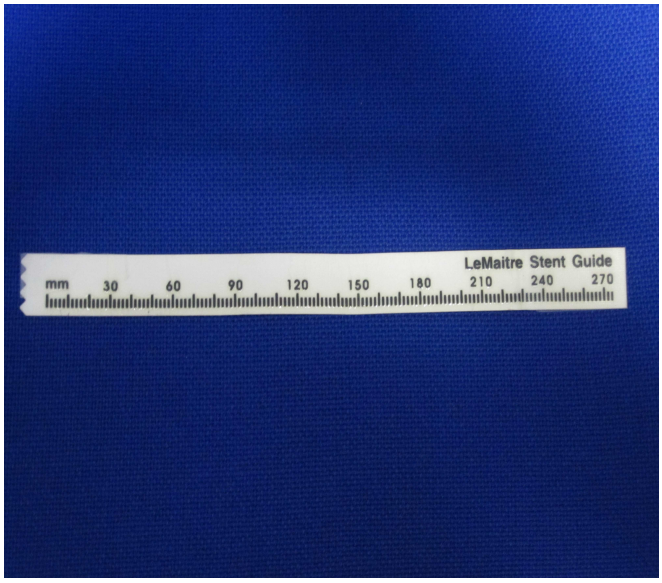


Figure 19. Radio-opaque ruler

Figure 20 . Ruler in bedpan

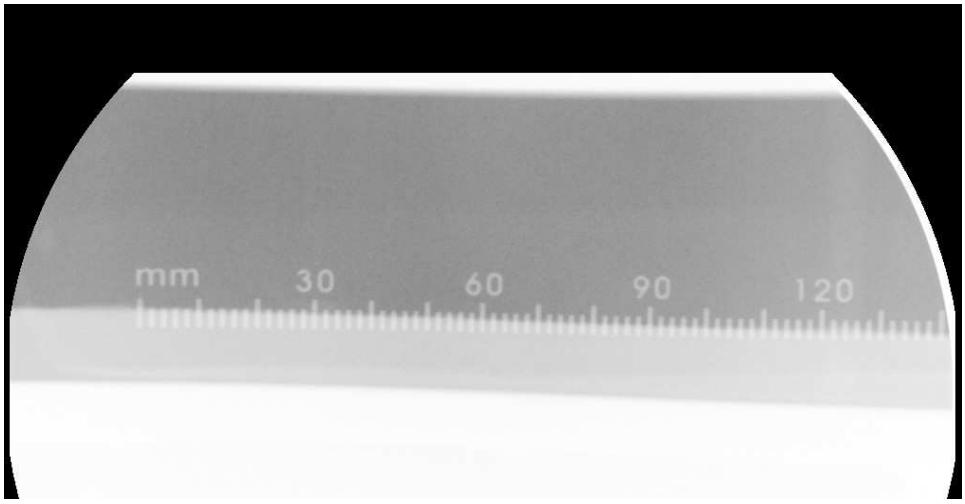


Figure 21. Phantom image of ruler used to calculate magnification factor

The method used in this study to measure PD did not utilise bony landmarks. In our Unit the image field is narrowed to reduce radiographic glare therefore the sacrum, coccyx and pubis are not consistently seen in all images. In this study the top of the commode seat was used as a consistent landmark. As in other published studies the anorectal angle was used to represent the level of the pelvic floor. Movement of the anorectal angle was measured in relation to the top of the commode seat. The anorectal angle is identified using the "posterior" method i.e. the angle between the longitudinal axis of the anal canal and a line drawn parallel to the distal half of the posterior wall of the rectum. The indentation of the posterior rectal wall caused by the puborectalis sling was used to aid identification. A horizontal line was drawn to mark the top of the commode seat and another horizontal line was drawn through the anorectal junction where the anorectal angle is formed. A perpendicular vertical line was then drawn between the two levels. This vertical distance was measured at rest and on straining and the difference between the two measurements is the PD. The proctogram recording was

also stopped on lifting the pelvic floor and on defaecation. A measurement was made in each position. The strain measurement was taken when there was maximum descent of the pelvic floor but prior to the opening of the upper anal canal which is indicative of the beginning of defaecation.

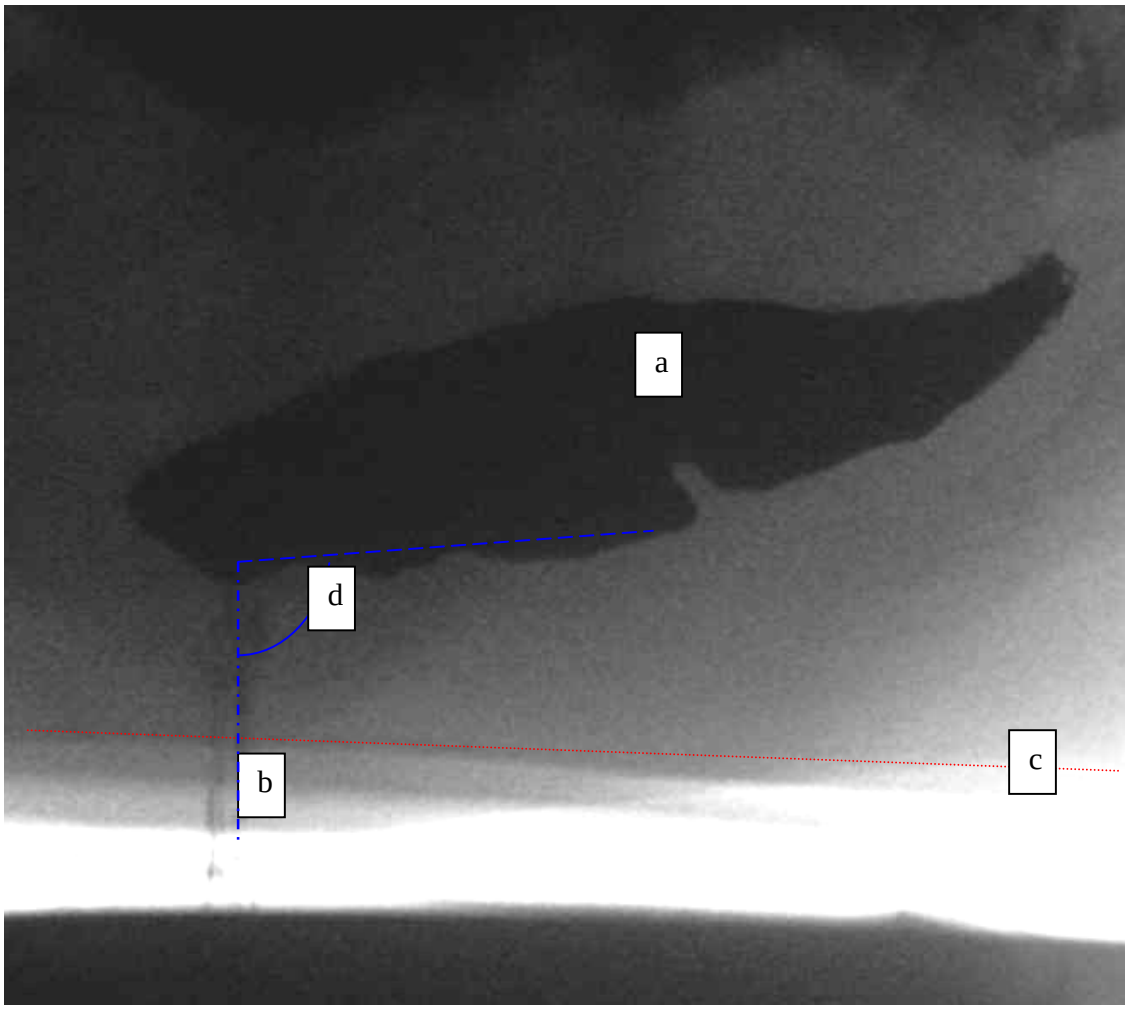


Figure 22. Proctogram image at rest

a = rectum, b = anal canal, c = top of commode, d = anorectal angle

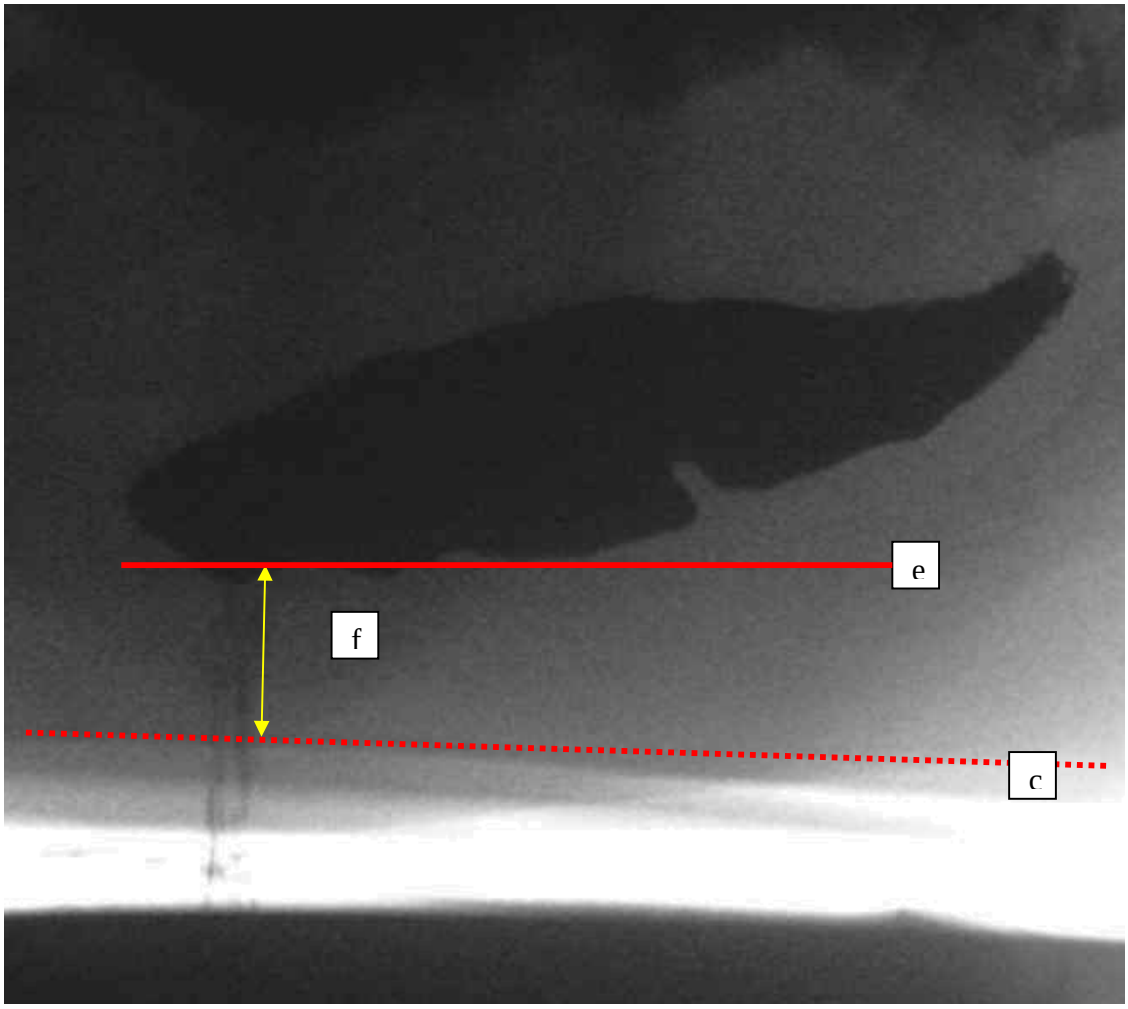


Figure 23. Proctogram image showing measurement of PD at rest

c = top of commode, e = anorectal junction, f = PERINEAL DESCENT AT REST

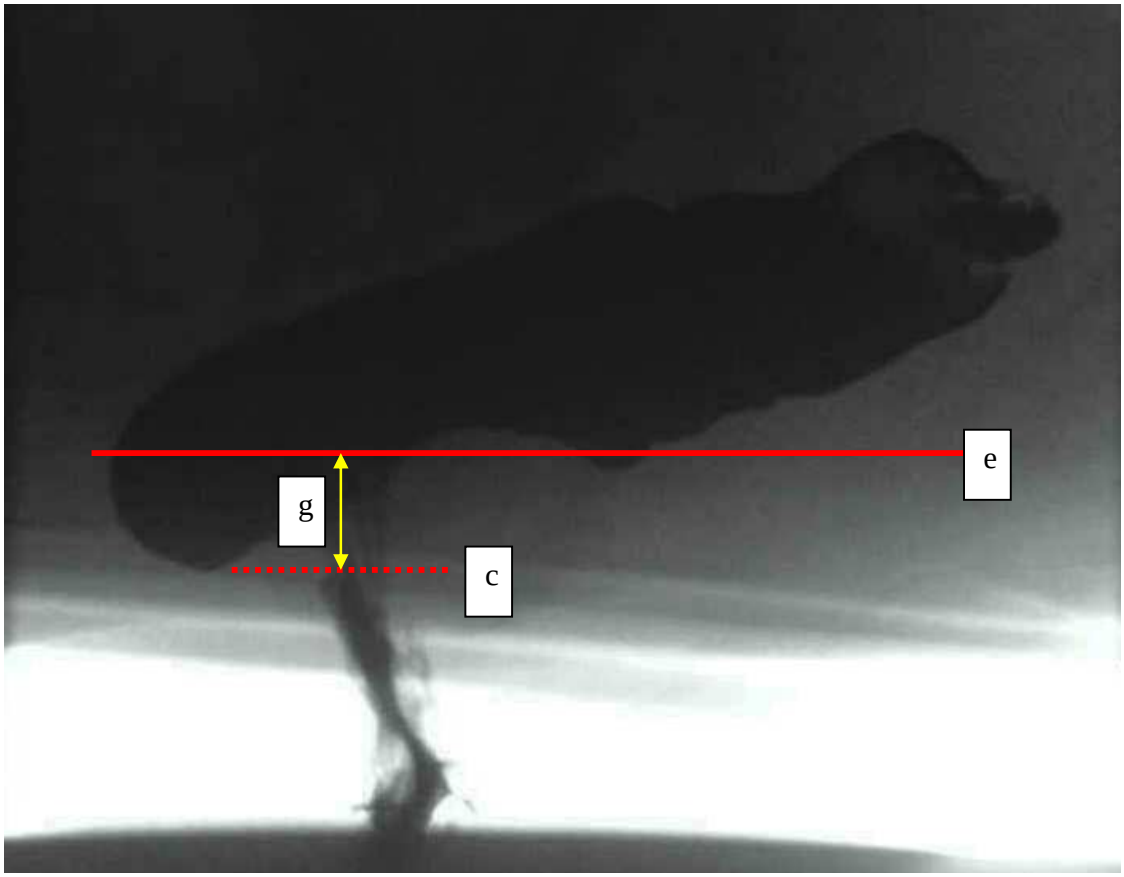


Figure 24. Proctogram image showing measurement of PD on straining

c = top of commode, e = anorectal junction, g= PERINEAL DESCENT ON STRAINING

2.4.4 Data analysis

Data analysis was performed using SPSS® for Windows version 16.0 (SPSS Inc, Chicago, IL). The level of agreement between the methods was assessed using Bland Altman analysis.

2.5 Results

The three methods for PD measurement were compared in 68 patients.

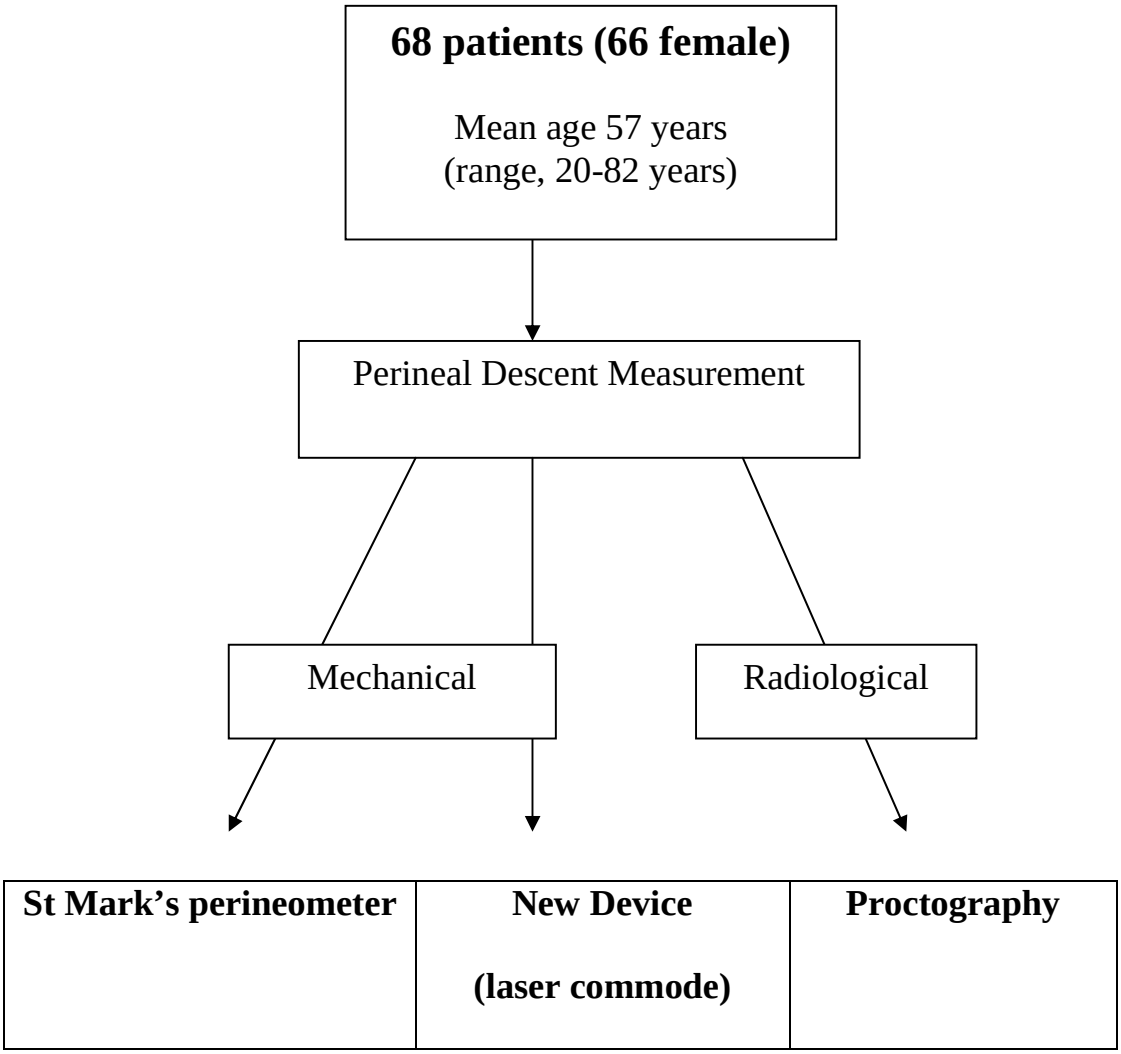


Figure 25. Perineal descent measurement using the three methods

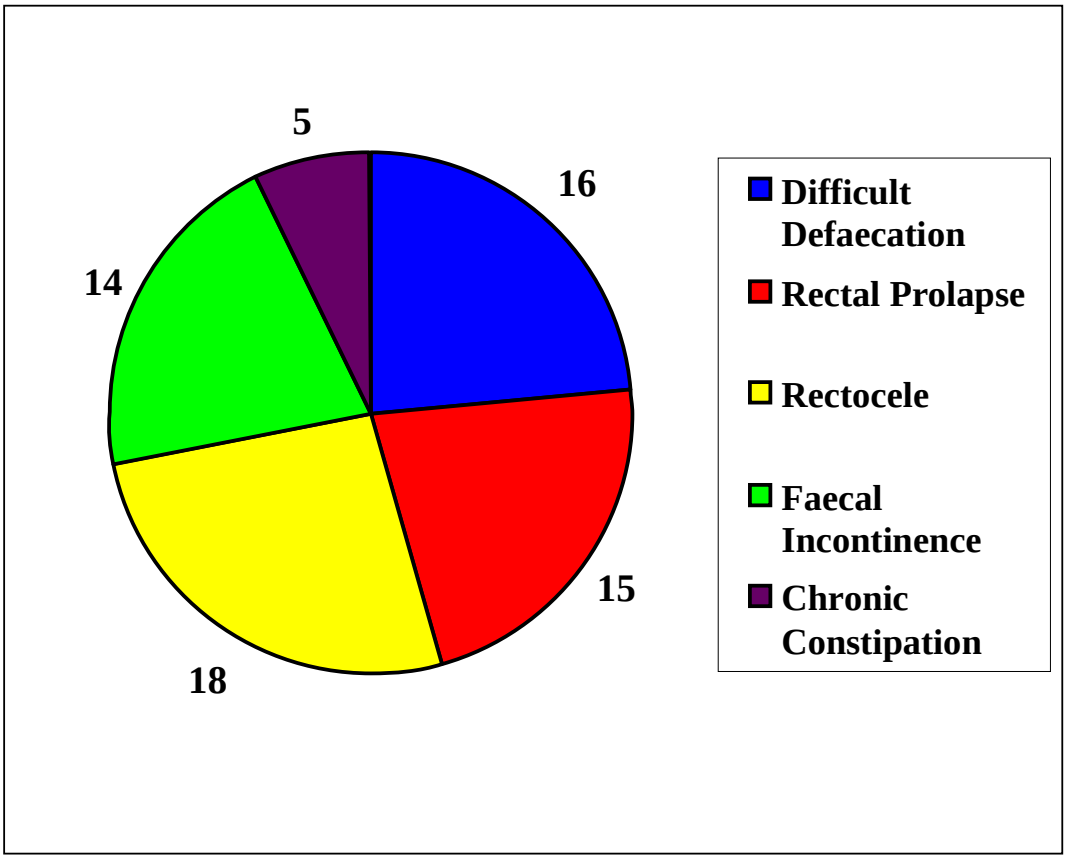


Figure 26. The number of patients with each clinical diagnosis

The PD is the distance (in centimetres) which the perineum moves during a strain effort. This is equal to the difference between the PD at rest and on straining.

2.5.1 Comparison of the mechanical devices and proctography- PD

The laser commode produces a more similar mean overall PD measurement to proctography than the perineometer (table 5). The mean PD measured by the perineometer is greater than that measured by proctography.

Table 5. Mean perineal descent measurements using the three methods

Perineal descent (cm)	Perineometer	Laser commode	Proctography
Rest	1.77	-2.18	-0.13
	± 1.38	± 1.12	± 1.07
Strain	0.68	-2.86	-0.92
	± 0.60	± 1.13	± 1.10
Overall	**1.09**	**0.67**	**0.79**
	± 0.65	± 0.37	± 0.59

Data are means ± SD measured in 68 patients using the two mechanical methods and proctography (SD, standard deviation)

A Bland Altman analysis was used to assess the level of agreement between the perineometer and proctography and, the laser commode and proctography. A range of agreement was defined as the mean bias ± two standard deviations.

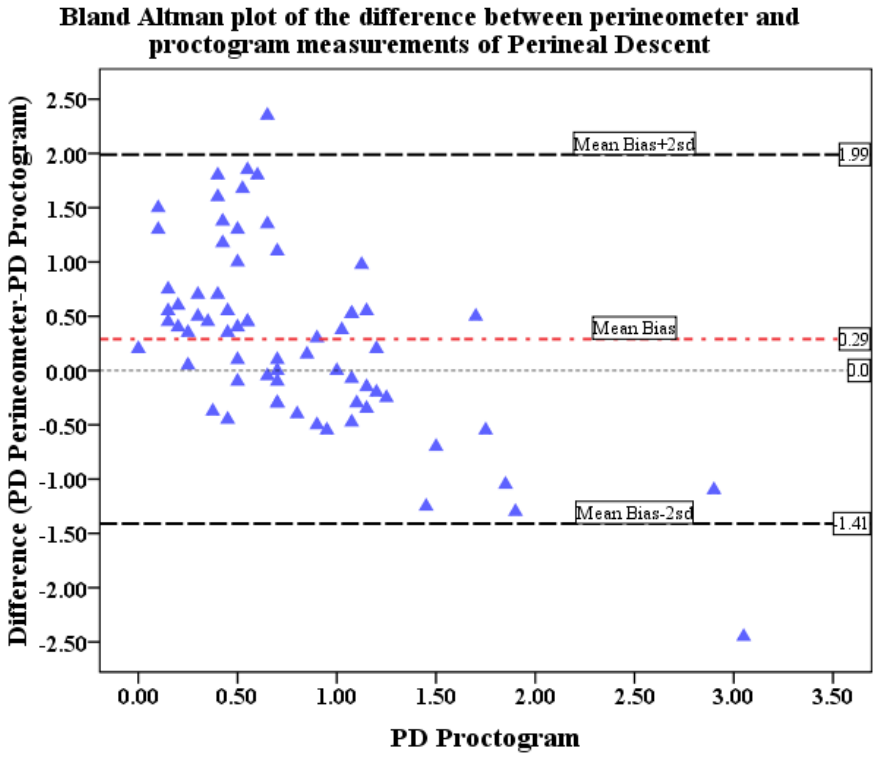


Figure 27. Bland Altman plot of the mean bias (0.29cm) and 95% limits of agreement between the perineometer and proctography measurements of overall perineal descent

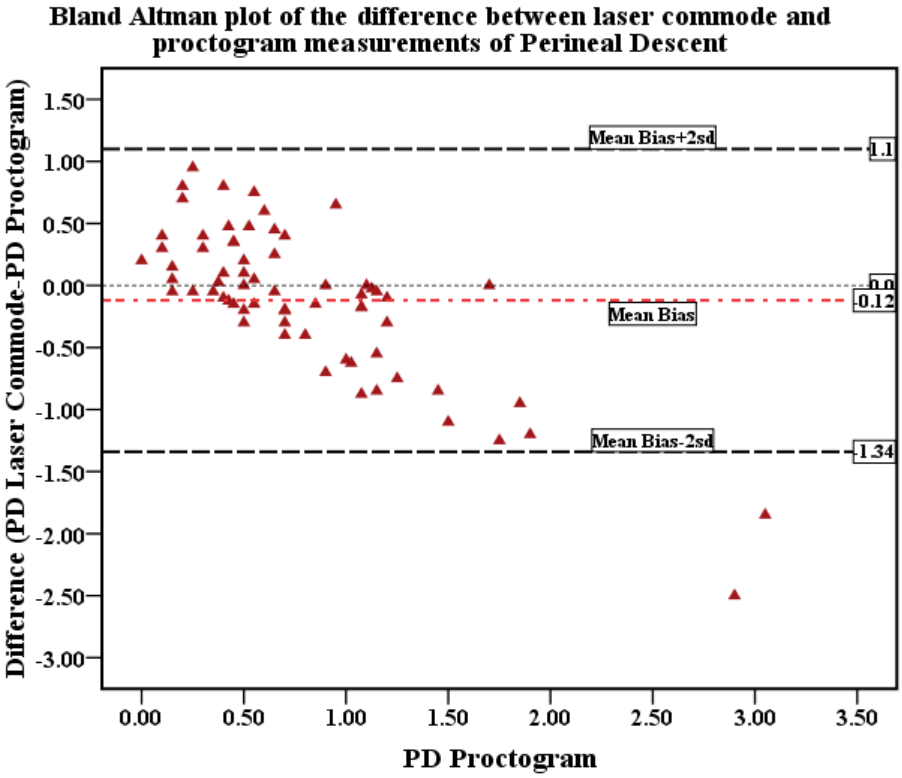


Figure 28. Bland Altman plot of the mean bias (-0.12cm) and 95% limits of agreement between the laser commode and proctography measurements of overall perineal descent

The mean bias of variation between the perineometer and proctography was 0.29cm, indicating an overestimate by the perineometer. The 95% limits of agreement range from -1.41 to 1.99cm. This implies that the extent of the discrepancy between the two methods could be as great as 1.99cm.

In the comparison of the laser commode and proctography the mean bias of variation was -0.12cm with 95% limits of agreement ranging from -1.34 to 1.10cm. The amount of variation between measurements taken by the laser commode and proctography was less than that between the perineometer and proctography (-0.12cm compared to

0.29cm), therefore the laser commode was more accurate than the perineometer compared to the gold standard method of measurement.

The negative mean bias value suggests that the laser commode under estimates PD, however, the pattern of the graph shows that the laser commode overestimates the value when a lesser degree of PD is found using proctography (less than 1.5cm) and underestimates it when a greater degree of PD is found using proctography. The two extremes are cancelled out to produce a mean bias which is close to zero (figure 28).

The wider limits of agreement between the perineometer and proctography show that there is greater variation between these two methods than the laser commode and proctography but again the pattern of the Bland Altman plot is similar with the perineometer overestimating PD when the proctography value is less than 1.5cm and underestimating PD at the other extreme (figure 27). It is possible to compare the mechanical devices more closely for different degrees of PD by categorising the data into three groups according to the PD value measured using proctography.

Table 6. Mean bias of variation between mechanical devices and proctography according to degree of perineal descent

	Perineometer	Laser commode
Group 1. PD 0-1cm	**0.57**	**0.13**
(n=47)	± 0.73 (-0.89 to 2.03)	± 0.38 (-0.63 to 0.89)
Group 2. PD 1-2cm	**-0.16**	**-0.54**
(n=19)	± 0.64 (-1.44 to 1.12)	± 0.46 (-1.46 to 0.38)
Group 3. PD >2cm	**-1.78**	**-2.18**
(n=2)	± 0.95 (-3.68 to 0.12)	± 0.46 (-3.10 to -1.26)

Data are mean bias ± SD and (95% limits of agreement)

Group 1 includes subjects with between 0 and 1cm of PD measured using proctography and it comprises 69% of the study population (47 subjects). With this degree of PD the laser commode provides measurements which are closer to that of proctography than the perineometer. This is demonstrated by comparison of the Bland Altman plots of the mean bias and limits of agreement for the mechanical devices in this group of patients (figures 29 and 30).

Group 2 includes 19 subjects with PD ranging from 1 to 2cm. In this subgroup the measurements of the perineometer appear to be closer to those of the proctogram as the mean bias of variation is only -0.16cm compared to -0.54cm with the laser commode (table 6). With both mechanical devices the limits of agreement are wide, therefore there is the potential for a clinically significant discrepancy between the devices and proctography in this group but the limits of agreement are wider in the case of the perineometer.

The final group 3 consists of two patients with PD measurements greater than 2cm. In this very small subgroup the discrepancy between the mechanical devices and proctography is most marked with a mean underestimate of 1.78cm in the case of the perineometer and 2.18cm in the case of the laser commode.

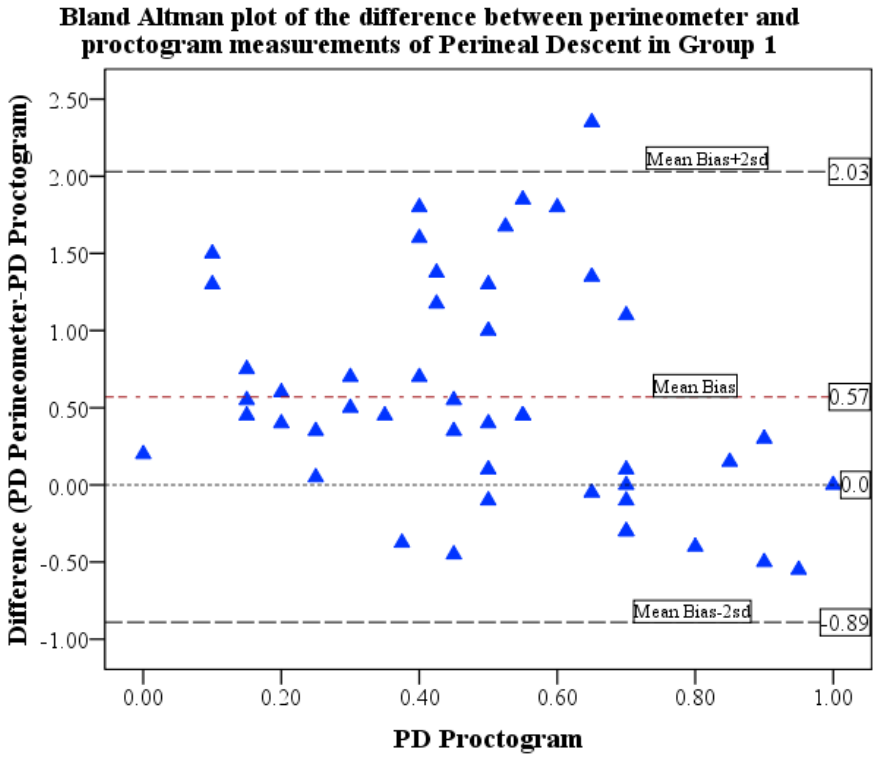


Figure 29. Bland Altman plot of the mean bias between perineometer and proctogram measurements of perineal descent in Group 1 (PD = 0-1cm)

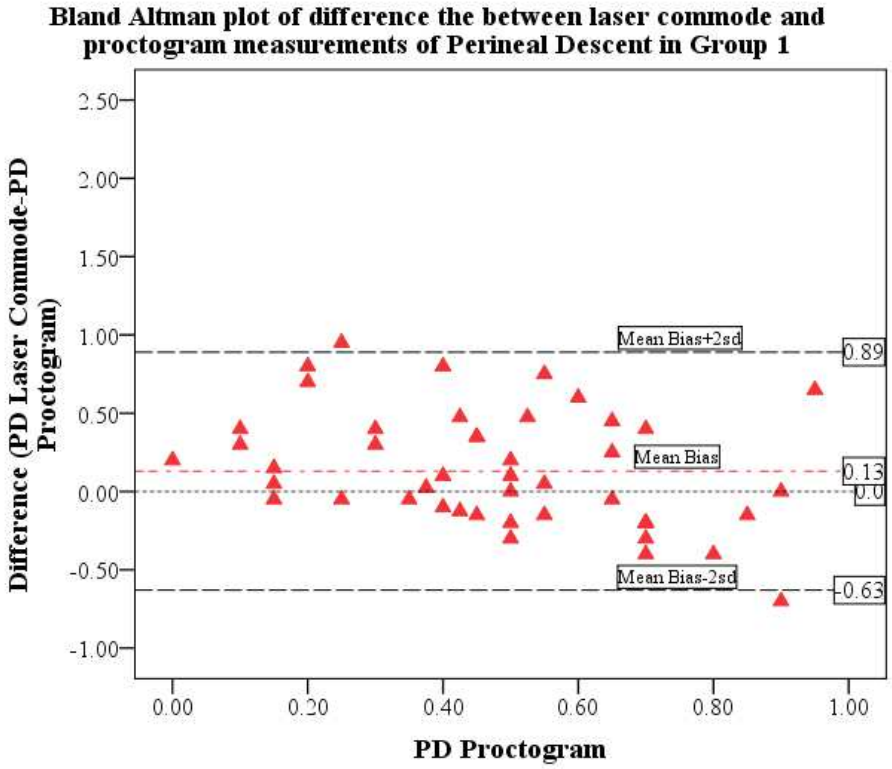


Figure 30. Bland Altman plot of the mean bias between laser commode and proctography measurements of perineal descent in Group 1 (PD = 0-1cm)

2.5.2 Comparison of the mechanical devices and proctography- perineal descent at rest and on straining

The resting PD measurements of both mechanical devices varied greatly compared to that of proctography. The mean resting PD was a negative value in the case of both the laser commode and proctography; this represents the effect of gravity on the perineum in the seated position, however, the mean PD at rest measured using the laser commode was -2.18cm. This was 2cm lower than the proctography measurement and 4cm below that of the perineometer (table 5). The starting point of the perineum is at a much lower level in relation to the ischial tuberosities when the laser commode is used.

Table 7. Mean bias of variation between mechanical devices and proctography for perineal descent at rest

Method of PD measurement at **rest**	Mean Bias (compared with Proctography) cm
Perineometer	**1.90** ± 1.37 (-0.84 to 4.64)
Laser commode	**-2.05** ± 0.99 (-4.03 to -0.07)

Data are mean bias ± SD and (95% limits of agreement)

There is more variation between the mechanical devices and proctography when PD at rest is measured compared to overall PD. Except in one case, when the laser commode was used the resting position of the perineum was always below the level of the ischial tuberosities. This meant the PD at rest was a negative value. The mean bias of variation between the laser commode and proctography was -2.05cm and the lower limit of agreement was as great as -4cm (this means the PD at rest measured using the laser commode could be up to 4cm further below the level of the ischial tuberosities than the level measured using proctography). The perineometer is equally inaccurate and over estimates descent by almost 2cm.

The level reached by the perineum when the patient is asked to bear down is the PD on straining. Using the perineometer the mean PD on straining was 0.68cm above the ischial tuberosities. The proctography measurement of mean PD on straining was -0.92cm but the laser commode measurement was almost 2cm below this level at -2.86cm (table 5).

Table 8. Mean bias of variation between mechanical devices and proctography for perineal descent on straining

Method of PD measurement on **straining**	Mean bias (compared with proctography) cm
Perineometer	**1.60** ± 1.59 (-1.58 to 4.78)
Laser commode	**-1.94** ± 1.02 (-3.98 to 0.10)

Comparison of each mechanical device to proctography for straining measurements shows a similar pattern to that of the measurements at rest with the perineometer measuring the perineum on straining at a higher level than proctography and the laser commode measuring it at a much lower (in relation to the ischial tuberosities) level (table 8).

2.5.3 Intra-rater repeatability of perineal descent measurement using the laser commode

In order to establish whether the laser commode can produce accurate repeat measurements and therefore be used in clinical practice, serial measurements were performed on the same occasion by the same observer on all 68 participants. PD at rest and on straining was measured three times with a break of 30 seconds between each measurement. The patient remained seated on the commode throughout.

In six cases two sets of measurements were completed and in two cases only one measurement was completed. Repeat measurements were omitted in these participants because of patient choice (concerns about incontinence) and time constraints.

A one-way ANOVA test was used to generate the within-subject standard deviation for each of the variables (PD at rest, PD on straining and overall PD) and this was used to calculate a coefficient of repeatability. See appendix 1.

Table 9. The coefficient of repeatability for each perineal descent measurement

Variable	Within-subject standard deviation	Coefficient of repeatability
Perineal descent at rest	0.28	0.77
Perineal descent on straining	0.33	0.91
Overall perineal descent	0.32	0.88

The maximum difference between repeated measurements of PD at rest within one individual was 0.77cm. The coefficient of repeatability is higher for both the PD on straining and the overall PD measurements; this suggests they are more likely to vary with repeated measurements.

2.5.4 Intra-rater test-retest reliability

This part of the study assessed the reproducibility of the laser commode technique for PD measurement when performed in the same subject by the same observer on a different day.

A total of four female patients were measured on two separate occasions. The mean age of the group was 55.5 years (range, 40-80 years). The second measurement was performed between 35 and 128 days following the first measurement; the patients did not receive any surgical intervention in the interim period. Two sets of measurements

were recorded on each day. See appendix 2. The number of participants measured on a second day is too small to determine whether there is a statistically significant difference between repeated measurements. The overall PD measurements taken on different days were similar in the majority of the subjects; this suggests the same degree of movement of the perineum was detected on both occasions. This was not the case with PD at rest. On each separate day the two resting measurements did not vary a great deal but the difference between the values on separate days was marked (the perineum was measured 1.3cm higher at rest on day 2 in subject number 2).

2.5.5 Inter-rater reproducibility

In order to establish the reproducibility of the laser commode technique PD was measured on the same occasion by two separate observers. The second observer repeated the measurements immediately after the first observer with a 30 second rest period in between measurements. The patient remained seated on the commode throughout. The second operator was instructed in the technique and given the opportunity to practice it by measuring ten patients before commencing this part of the study. Consistent verbal instructions were given to the patients and the observers were blinded to the results.

PD was measured by two observers in 25 female patients. The mean age of this group was 58 years (range, 37-75 years). Uterine or vaginal prolapse was the presenting problem in 20 patients (80%), cystocele was the main diagnosis in three patients and the

remaining two patients were being treated for rectocele. The subjects were measured first by myself then by operator 'KR'.

Table 10. Mean bias of variation between perineal descent measured by two observers

Perineal descent	Mean bias (between observer 1 and observer 2) cm
Rest	**0.14** ± 0.33 (-0.50 to 0.82)
Strain	**0.02** ± 0.35 (-0.68 to 0.72)
Overall	**0.14** ± 0.32 (-0.50 to 0.78)

Data are mean bias ± SD and (95% limits of agreement) for 25 subjects

A Bland Altman analysis was used to assess the level of agreement between the two observers and as in other parts of the study the range of agreement was defined as the mean bias ± two standard deviations. See appendix 3.

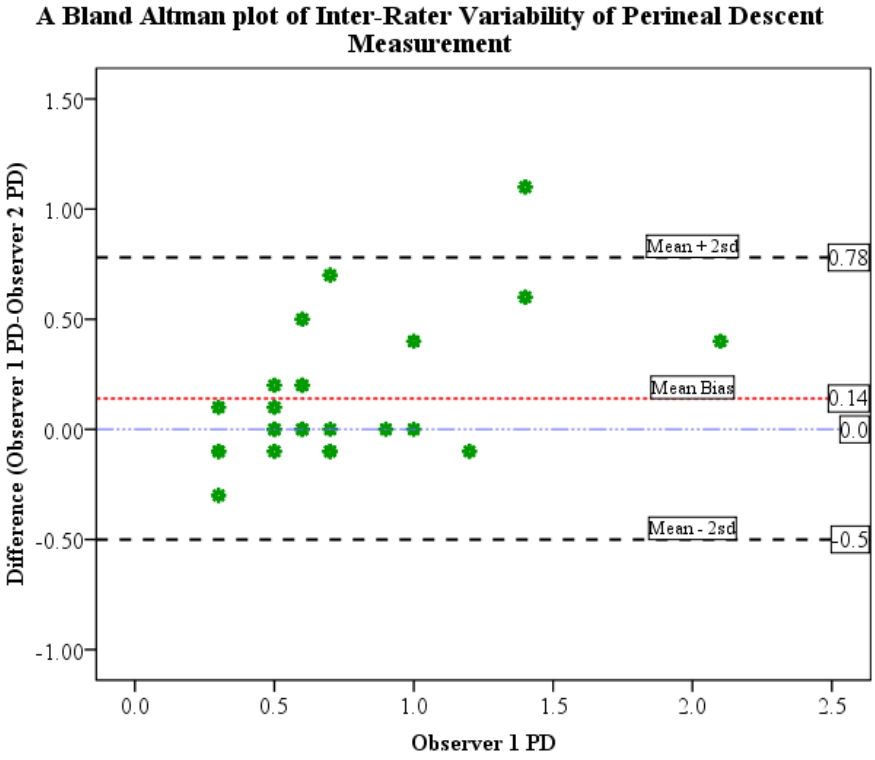


Figure 31. Bland Altman plot of the mean bias (0.14cm) and 95% limits of agreement between perineal descent measurements of two observers

The mean bias of variation between consecutive measurements of PD taken by two observers is low at 0.14cm. The 95% limits of agreement show that any discrepancy will be less than 1cm, this would be clinically acceptable.

2.6 Discussion

The aim of this study was to determine the accuracy of a new non-radiological device for PD measurement that might be of use in other areas of this project. This was achieved by comparing the new device (the laser commode) and the established mechanical device for PD measurement (the perineometer) to the current gold standard method of measurement, defaecating proctography in 68 patients with pelvic floor disorders.

The mean PD measurement of the laser commode was closer to that measured by proctography (0.67 versus 0.79cm) than the perineometer measurement (1.09 versus 0.79cm). The mean bias of variation between the PD measurements of the laser commode and proctography was less than that between the perineometer and proctography (-0.12 and 0.29cm respectively). This suggests that the laser commode is a more accurate method of measuring overall PD than the perineometer in this study of 68 patients.

With both mechanical devices the mean bias of variation is relatively small. If the difference between the mechanical devices and the gold standard measurement is only 1 to 2mm this would be considered clinically acceptable, however, the pattern of both Bland Altman plots show that the devices overestimate the measurement when the patient has less PD and underestimate it when the patient has a more severe degree of PD. This results in a mean bias which is nearer to zero. The majority of the study group

(69%) had less than 1cm of PD measured by proctography, in these patients the laser commode was more accurate. In the 19 patients with 1 to 2cm of PD the perineometer was more accurate but in the two subjects with greater than 2cm of PD both mechanical devices produced unacceptable underestimates with the perineometer performing slightly better than the laser commode.

The laser commode is more accurate than the perineometer in measuring overall PD in this group of 68 patients but to replace the perineometer in clinical practice the laser commode must be able to produce measurements that consistently agree with those of proctography. The limits of agreement between the laser commode and proctography are smaller than those between the perineometer and proctography but in both cases the potential discrepancy between the device measurements and those of proctography are too great to be clinically acceptable. Although the laser commode was most accurate when measuring subjects with less than 1cm of PD, the limits of agreement were -0.63 to 0.89cm. An overestimate of 0.89cm would be clinically unacceptable in a group of patients with an actual overall PD of 0 to 1cm.

The intra-rater reliability of the laser commode technique was assessed by comparing the variation of PD measurements made on the same subject by the same operator on the same day in all 68 patients. The maximum expected difference between overall PD measurements in the same subject was 0.88cm. Descent of the perineum is reliant on patient effort which is affected by fatigue, fear of incontinence and difficulties with comprehension of the instructions. This explains the higher variability seen with the PD

measurements on straining where a maximum within-subject difference of 0.91cm was found. The patients remained seated on the commode throughout therefore we would expect the resting PD to remain the same for each set of measurements. The coefficient of repeatability suggests that the PD at rest can vary by a maximum of 0.77cm. This may be due to both patient and operator factors. The patient may alter their position on the commode and after repeated strain efforts the perineum may not ascend to the original level. The laser distance measurer is activated by the operator, this is subjective and it is possible that a measurement can be taken before the perineum has returned to the resting position. The distance measurer is accurate to ± 1.5mm but the accuracy of the measurement is reliant on the operator activating the measurer when maximum descent is achieved. This may be further affected by a possible delay of up to 0.5 seconds which is the time that it may take to make the measurement. The laser is directed at the perineum just anterior to the anal verge at the 12 o clock position. Minute adjustments of the position of the laser between measurements may result in a different resting PD with repeat measurements.

Only four patients completed a second set of measurements on a different occasion. This was due to difficulty arranging for patients to attend for a second time and because some patients had undergone surgery in the interim period which would alter their perineal descent. It is therefore not possible to comment on the test-retest reliability of the laser commode, however, this data does show a degree of variability in resting measurements which is likely to reflect the difficulties in ensuring consistent positioning of the patient on the commode seat.

The reproducibility of the laser commode was assessed using two operators to perform measurements on the same subject on the same occasion in a subgroup of 25 patients. The mean bias of variation for overall PD was acceptable at 0.14cm (0.14cm for PD at rest and 0.02cm for PD on straining) with limits of agreement of -0.50 to 0.78cm. Biological measurements will not be exactly the same on every occasion and some degree of variation between measurements is to be expected but in this study the maximum difference between repeated measurements and the potential discrepancy between observers (-0.50 to 0.78cm) suggest the laser commode would not be reliable enough to provide repeat measurements in a clinical setting.

In comparison to the device proposed by Morren et al in 2004 which comprised a modified commode and magnet [177] the laser commode is inexpensive, non-invasive and simple to use. Unlike the perineometer it also utilises the more physiological sitting position. The mean PD at rest measurements of the laser commode and proctography are lower than the level of the ischial tuberosities; to some degree this reflects the pull of gravity in this position, however, the laser commode mean resting PD is 2cm lower than that of proctography. This is likely to be due to the shape of the commode seat which minimises support for the perineum and forces it to descend through the aperture. The commode seat used during proctography more closely resembles that of a conventional toilet. The laser commode may produce a degree of descent at rest which is not likely to occur during normal defaecation.

In contrast to previous work, the current study found that the perineometer overestimated PD in comparison to proctography. Henry originally developed the perineometer and used it to measure 20 patients with clinical evidence of PD and 103 control patients.[62] A mean descent of 3.2cm was measured in the PD group which is considerably more than the mean descent of 1.09cm found using the perineometer in this study. The patients in Henry's study were however selected because they had a significant degree of PD on clinical examination; this was not the case in the current work.

The perineometer may record greater degrees of descent than the laser commode and proctography in this study because of variations in patient weight and strain effort, and operator technique. Body mass index was not recorded in either the current study or the work by Henry in 1982.[62] A large amount of subcutaneous tissue overlying the ischial tuberosities will move the frame of the perineometer away from the perineum and if the buttocks have to be retracted this will also affect the accuracy of the PD measurement. As the weight of the population as a whole has increased over the last 30 years it is likely that the current study group are bigger than those observed by Henry.[62] The perineometer is used in the left lateral position, patients may not fear incontinence when lying down and therefore produce more strain effort than when they are seated on the laser commode. A firm degree of pressure applied to the perineometer frame by the operator results in a greater degree of descent. This study could be improved by using a second operator to perform perineometer measurements in order to evaluate the reproducibility of the technique.

In 1985 Oettle measured PD in 21 patients using the perineometer and proctography. [72] The perineometer was found to underestimate descent by 60%. The proctographic method of PD measurement used the distance from the anorectal angle to the pubococcygeal line. The anal canal shortens during a strain effort and as the perineometer measures movement of the anal verge and not movement of the higher anorectal angle Oettle suggested that this may contribute to the difference in measurements.

The mean PD measured on proctography in the Oettle study was 2.9cm (range 0.9 to 5.2cm) [72] in comparison to a mean of 0.79cm (range 0 to 3.05cm) in our study. The level of the anorectal angle was used to represent the pelvic floor in the current study but the lower level of the commode seat was used as a consistent landmark. This landmark was also used in Selvaggi's study of 10 asymptomatic patients in 1990 [80] but like the work of Oettle the mean PD was greater than in our study (2.72cm). This suggests that either the patients in the current study have less descent than those included in previous work or the current technique of proctographic measurement is inaccurate. This method is explored further in Chapter 4. The measurements in the current study were adjusted to compensate for the use of magnification; this was also the case in the Oettle and Selvaggi work. The strain measurement is made on proctography just before the anal canal opens, it is possible that this measurement was taken at a later point in the strain effort in the previous work thus capturing a greater degree of descent.

Proctography was considered to be the "gold standard" method for PD measurement in this study but as stated in chapter 1 it is not without problems. A magnification factor was applied to try to correct for the use of fluroscopy but slight alterations in patient positioning and greater variation in patient size may have affected the accuracy of this. A prospective approach measuring patients with the mechanical devices on the day of their proctogram and then carrying out the radiological measurements would have been preferable but time constraints imposed by the difficulties with ethical approval made this impossible. The radiological measurements were therefore carried out retrospectively meaning variable amounts of time had elapsed between the proctograms and the mechanical measurements.

With regards to the laser commode, the study may have been improved by shaping the seat to be more consistent with that of the proctogram commode seat and also by using a laser distance measurer that could provide a continuous measurement during straining so that a curve representing pelvic floor movement was produced rather than an isolated measurement. Allowing adjustment of the commode chair height for each individual so that the hips and knees are flexed to 90 degrees on every occasion would ensure the best possible position for "bearing down" on each occasion.

Summary

In this study of 68 patients with pelvic floor dysfunction the laser commode was found to be a more accurate method of PD measurement than the perineometer compared to the gold standard, defaecating proctography. The repeatability and reproducibility of the laser commode measurements were not however acceptable and this will limit the usefulness of this device in a clinical setting.

By using the commode top as a reference point for both the proctography and laser commode measurements, and the area anterior to the anus as a fixed point for both the perineometer and laser commode measurements the design of the study aimed to consistently measure the same type of movement with all three methods. Despite this the three methods are very different. Unlike the laser commode, proctography measures movement at the level of the anorectal angle which is proximal to the perineum and the examination is centred around rectal evacuation rather than straining. The perineometer is used in the left lateral position and measurements are subject to operator technique and patient habitus. The design of the laser commode produces an apparent degree of severe descent at rest which may not be an accurate representation of the clinical findings. The three methods may not be directly comparable although they may each provide useful information about pelvic floor movement.

Chapter 3. The relationship between perineal descent and joint hypermobility

3.1 Aims

The aim of this study was to determine whether there is a positive correlation between PD and joint mobility.

3.2 Patients

Ethical approval was obtained from the Greater Manchester East Research Ethics Committee and written consent was taken from all participants (REC Reference Number 10/H1013/81).

As in the previous study all participants were patients with symptoms of faecal incontinence, difficult defaecation or rectal prolapse who were under the care of the Pelvic Floor Unit at the University Hospital of South Manchester. Potential participants were identified from Outpatient and Radiology department records and they were recruited in the manner described in chapter 2. The same inclusion and exclusion criteria were also used. Age, parity, clinical pelvic floor problem and menopausal status were recorded for each patient.

3.3 Methods

3.3.1 Joint mobility assessment (Beighton score)

The Beighton score incorporates assessment of the mobility of the thumbs, fifth metacarpophalangeal joints, elbows, knees and spine.[133] The patients were evaluated

at the time of attendance for Outpatient review or proctography examination. The test was carried out by a single researcher. The patients were asked to perform each of the manoeuvres once; a score of one was recorded for each positive finding.

Table 11. The Beighton scoring system

	RIGHT	**LEFT**
1. Forward flexion of trunk with knees straight and palms on floor	1	
2. Hyperextension of elbow to $\geq 10°$	1	1
3. Hyperextension of knee to $\geq 10°$	1	1
4. Opposition of thumb to volar aspect of ipsilateral forearm	1	1
5. Passive dorsiflexion of metacarpophalangeal joint to $\geq 90°$	1	1
Maximum Total	**9**	

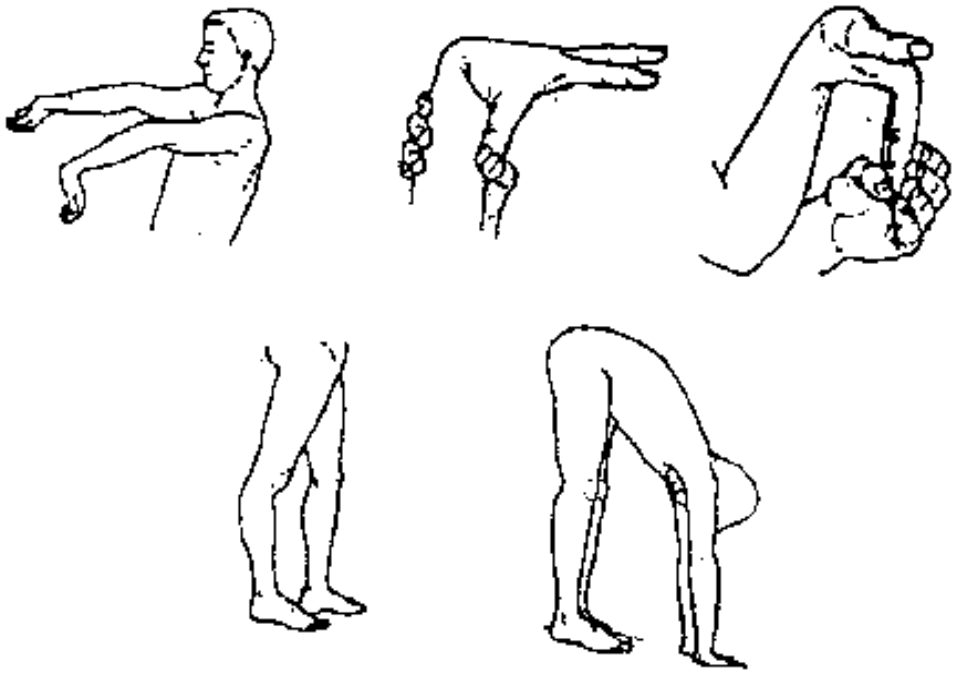


Figure 32. The Beighton score manoeuvres
(reproduced from Arthritis Research Campaign information booklet - Joint Hypermobility)

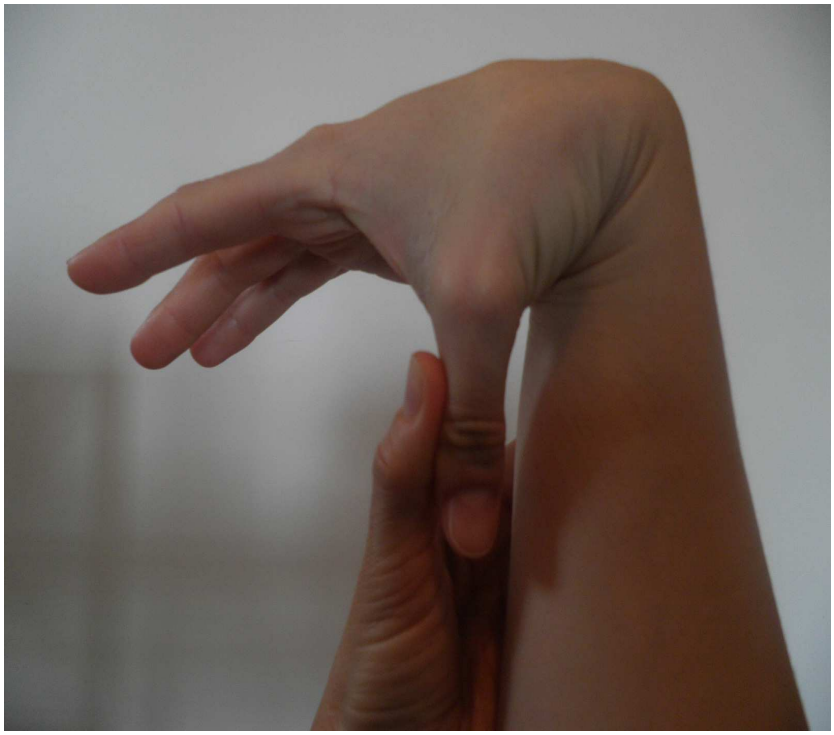


Figure 33. Hypermobility of the right thumb

3.3.2 Perineal descent measurement – defaecating proctography

The proctogram images were reviewed retrospectively and PD was measured using the method described in the previous study (chapter 2).

3.3.3 Data analysis

Data analysis was performed using SPSS® for Windows version 16.0 (SPSS Inc, Chicago, IL). Correlation coefficients for parametric and non-parametric data were used to look at the relationship between the pairs of variables including PD and parity, age and Beighton score. As this study did not explore the relationship between an outcome and a predictor multivariate regression analyses were not performed. For each variable subjects were separated into groups according to the presence or absence of joint hypermobility, positive or negative screening tool result, parity or nulliparity and PD greater or less than 1.5cm. The distribution of clinical diagnoses in the groups was compared using a chi square test. Comparison of the mean PD measurements and Beighton scores between the relevant groups was compared using independent sample t tests.

3.4 Results

A total of 70 female patients were recruited, 51 (72.9%) were post menopausal. The mean age was 58 years (range, 20-82 years). The median Beighton score was 0 (range, 0-6) and the median PD distance was 0.55cm (range, 0- 3.05cm). The most frequently positive Beighton manoeuvre was forward flexion of the trunk (present in 25.7 %).

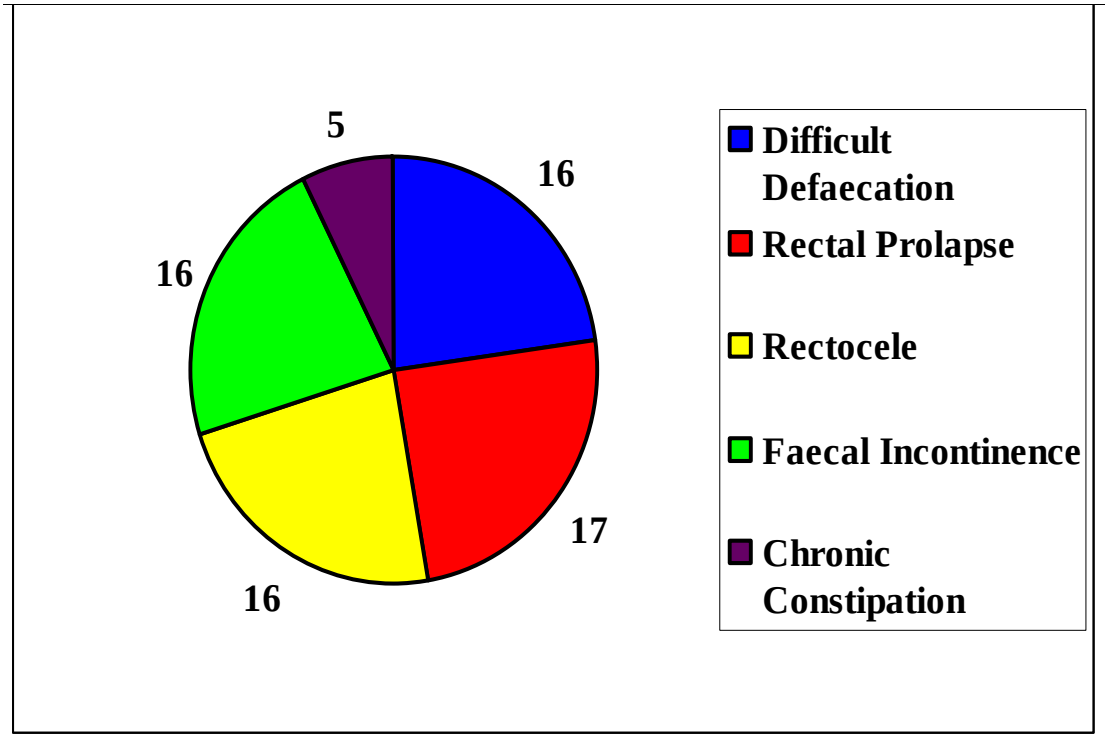


Figure 34. The number of patients with each clinical diagnosis

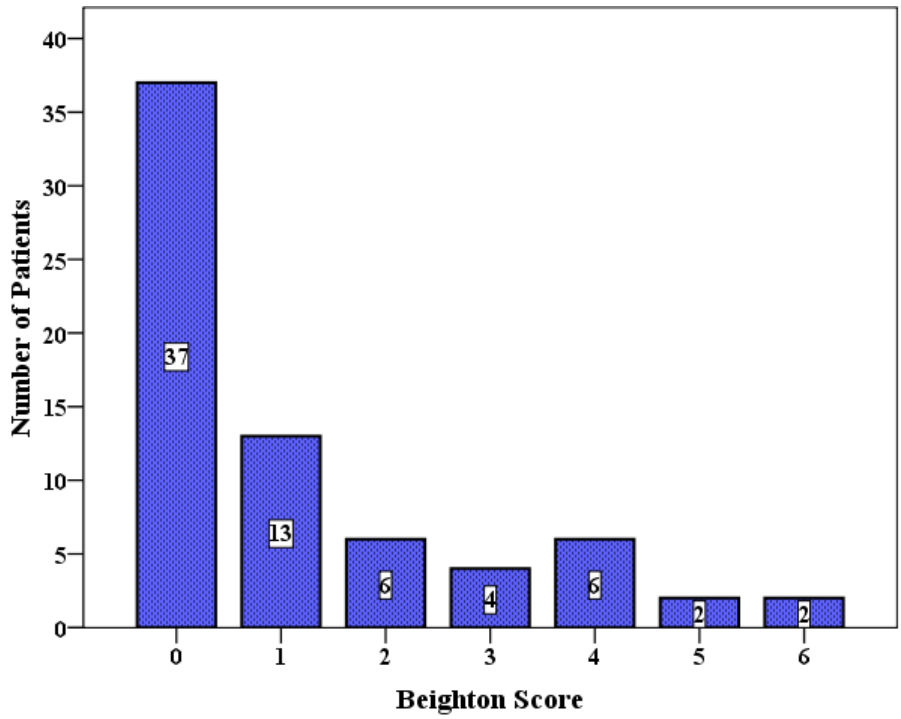


Figure 35. Frequency of Beighton score in 70 female patients

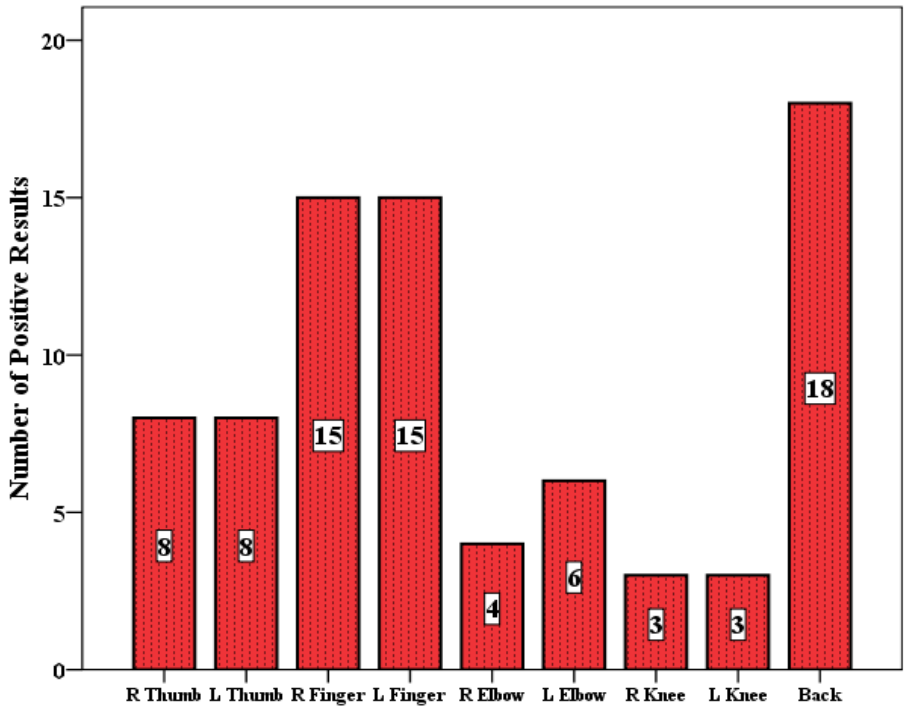


Figure 36. The number of positive findings for each Beighton manoeuvre in 70 female patients

3.4.1 Beighton score and PD

There was no correlation between PD and Beighton score (Spearman correlation coefficient 0.04, p= 0.77), this is demonstrated in Figure 37. Contrary to the hypothesis that joint hypermobility should be associated with the most severe PD, the subject with the greatest degree of PD had normal joint mobility with a Beighton score of zero.

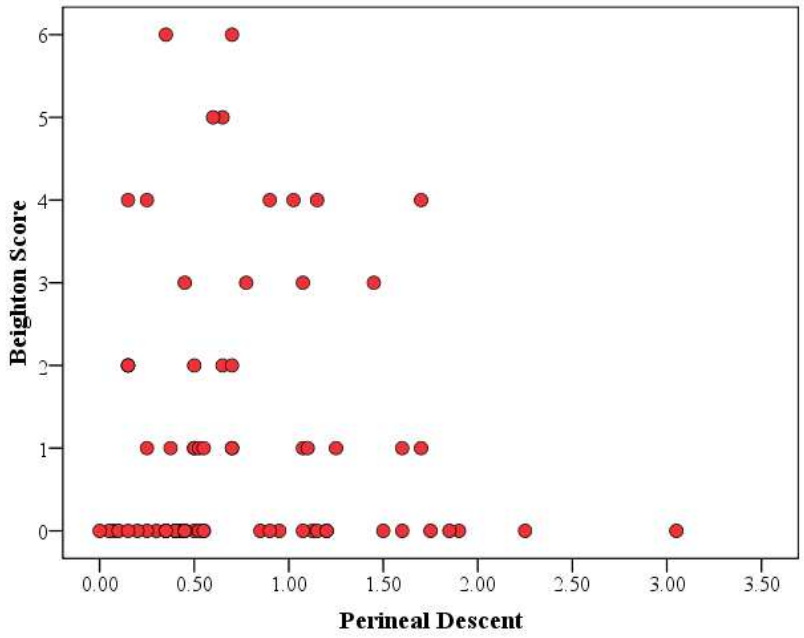


Figure 37. Scatter plot showing no correlation between the perineal descent measurements and joint mobility scores of 70 female patients

Table 12 . Correlation of perineal descent parameters with Beighton score

Parameter correlated with Beighton score	Test	Correlation Coefficient	P Value
PD at rest	Spearman	0.12	0.33
PD on straining	Spearman	0.11	0.38
Overall PD	Spearman	0.04	0.77

A Beighton score of 4 or greater is an indicator of generalised joint hypermobility. In this study group as a whole, the Beighton score did not correlate positively with the degree of PD. However, only ten subjects had a significant score of 4 or greater, therefore a subgroup analysis was performed within these patients.

The ten patients with hypermobile joints were younger than those with normal joint mobility (mean age 44 years versus 60 years). There was no statistically significant difference in the distribution of clinical diagnoses between the two groups.

Table 13. Perineal descent measurements of patients with and without joint hypermobility

Groups	Mean PD at rest (cm)	Mean PD on straining (cm)	Mean PD (cm)
1. Joint hypermobility Beighton score ≥ 4 (n=10)	0.51 ± 1.22	-0.24 ± 1.39	0.75 ± 0.47
2. Normal joint mobility Beighton Score < 4 (n=60)	-0.26 ± 1.02	-0.96 ± 0.99	0.78 ± 0.61
P value	**0.04***	0.05	0.89

Data are means ± SD measured using proctography in 10 patients with joint hypermobility and 60 patients with normal joint mobility, compared using t test
****significant at 0.05 level***

The mean PD achieved by both groups was similar (0.75cm in the hypermobility group versus 0.78cm in the normal mobility group) but there was significantly more descent at rest in the normal mobility group with the mean starting position of the perineum lying 0.75cm below that of the hypermobility group. There was no difference between the levels reached on straining.

3.4.2 Clinical pathology and PD

Of the 70 participants in the study ten had an overall PD measurement of 1.5cm or greater. There was no significant difference in the mean Beighton scores of the patients with PD <1.5cm and those with PD ≥ 1.5cm (0.60 ± SD 1.27 versus 1.28 ± SD1.71, compared using t test, p=0.23). There was, however, a difference in the clinical presentation of the 10 patients with PD ≥1.5cm. Chronic constipation was the presenting feature in 70% of this group compared to only 3.3% of the group with PD <1.5cm (compared using chi-square test, p=0.00).

3.4.3 Beighton score and age

The Beighton score decreases as age increases (see figure 38), this is expected as joints become less mobile with advancing age.[133] This is also reflected when comparing the joint mobility scores of the women according to menopausal state. The mean Beighton score of the 16 pre-menopausal women was three times greater than that of the 51 post-menopausal women (2.44 ± SD 2.03 versus 0.82 ± SD 1.38 compared using t test, p =0.00). Menopausal state was unknown in three cases.

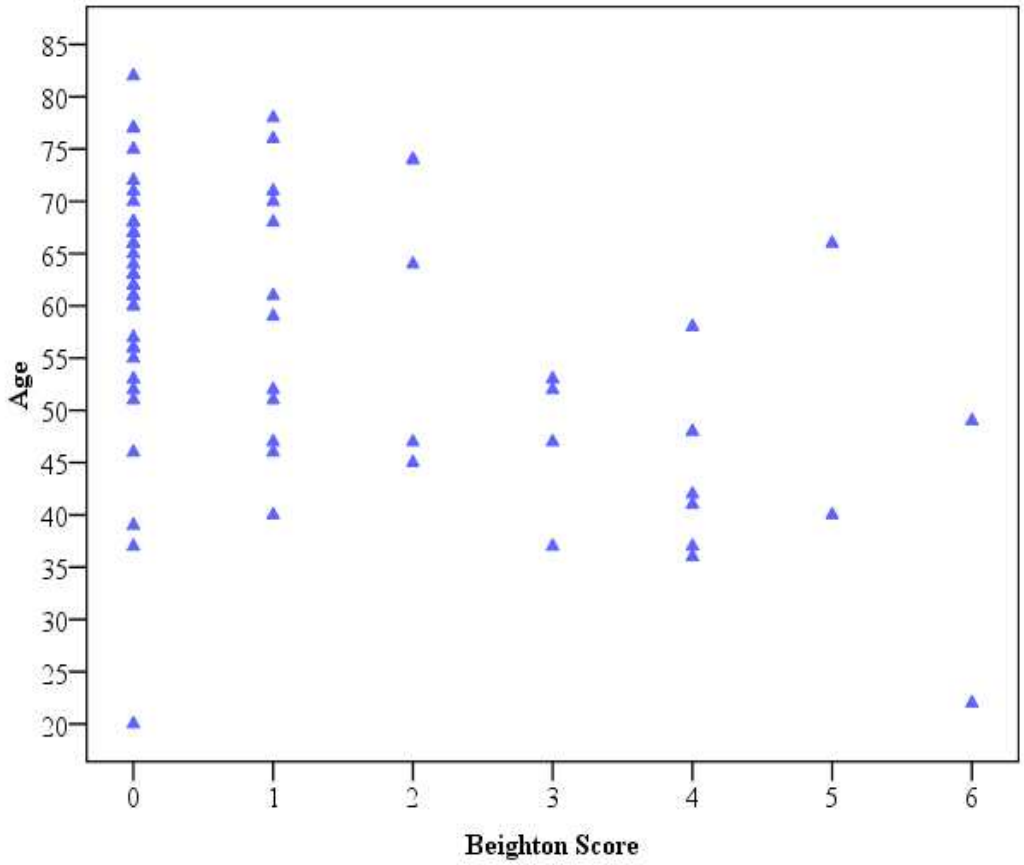


Figure 38. Scatter plot showing negative correlation between age and Beighton score (Spearman correlation coefficient -0.39, p=0.01)

Interim analysis of the first 20 subjects found the mean Beighton score to be low at 1.35. The mean age of the group at this point was 63 years (range, 45-78 years), Beighton score alone may not accurately reflect joint mobility in an elderly population therefore an additional screening tool assessment was included for subjects greater than 50 years of age recruited from this stage onwards.

Figure 39. Joint hypermobility screening tool [148]

1. Can you now or could you ever place your hands flat on the floor without bending your knees?
2. Can you now or could you ever bend your thumb to touch your forearm?
3. As a child could you contort your body or could you do the splits?
4. As a child or teenager did your shoulder or kneecap dislocate on one or more occasion?
5. Do you consider yourself to be double-jointed?

A score of 2 or more signifies a history of joint hypermobility. The screening questionnaire was completed by 29 participants. Nine subjects scored 2 or more. There were no significant differences between the mean Beighton scores or the mean PD measurements of those with a positive screening tool result and those who scored less than 2. No correlation between screening tool score and any of the parameters of PD was found (compared using independent samples t test). Of the nine subjects with a positive screening tool result only one also had a significant Beighton score of 4. The remaining patients scored 0 (4 cases), 1 (3 cases) and 2 (one case) using the Beighton assessment. This shows that the questionnaire was able to detect joint hypermobility in 8 cases where the Beighton score did not.

3.4.4 Parity and PD

Pregnancy and childbirth are thought to be major contributing factors to the development of pelvic floor pathology and PD. In order to determine the effect of connective tissue abnormality (represented by joint hypermobility) on PD without the influence of childbirth, the data of the nulliparous subjects was compared to that of the parous women.

The mean parity of the group was 2 children (range, 0-5); nine of the participants were nulliparous. There was a weakly negative correlation between parity and PD, the nulliparous subjects and those with fewer children were found to have greater degrees of PD. (Overall PD was not normally distributed therefore a Spearman correlation coefficient was used).

Table 14. Correlation of perineal descent parameters with parity

Parameter correlated with parity	Test	Correlation coefficient	P value
PD at rest	Pearson	-0.14	0.26
PD on straining	Pearson	0.02	0.84
Overall PD	Spearman	-0.32	**0.008***

significant at 0.01 level

The nulliparous women presented at an earlier age than the parous women (mean ages 46 and 60 years respectively). A chi-square test did not show a significant difference in the distribution of clinical diagnoses between the two groups. The mean Beighton score was 1.44 in the nulliparous group and 1.15 in the parous group, this difference was not statistically significant (compared with t test, p =0.62).

Table 15. Perineal descent measurements in nulliparous and parous groups

Groups	Mean PD at rest	Mean PD on straining	Mean overall PD
1. Nulliparous (n=9)	-0.08 ± 1.20	-1.11 ± 0.81	1.30 ± 0.80
2. Multiparous (n=61)	-0.16 ± 1.07	-0.82 ± 1.11	0.69 ± 0.52
P value	0.84	0.46	**0.003***

Data are means ±SD measured using proctography in 9 nulliparous and 61 multiparous women, compared using t test
****significant at 0.01 level***

The mean PD measurement of the nulliparous subjects is 50% greater than that of the parous group. There is no statistically significant difference between the groups in terms of rest or strain measurements.

3.5 Discussion

The aim of this study was to determine whether there is a positive association between joint hypermobility and PD. Joint mobility was assessed using the validated Beighton score and PD was measured using the current gold standard method, defaecating proctography.

There was no correlation between Beighton score and PD in the 70 female subjects included in this study. Previous work has shown a link between both urogenital prolapse and joint hypermobility and rectal prolapse and joint hypermobility.[135, 174] Prolapse occurs because of inadequacy of the supporting tissues of the pelvic floor. As PD is also thought to be a consequence of stretching of these connective tissues we would expect to find a similar association between PD and joint mobility. The fact that a positive relationship does not exist in this group may suggest that the development of PD is a separate phenomenon which does not involve the same pathophysiological processes as that of pelvic organ prolapse. Alternatively the relationship may exist but the methods utilised in this study may not be robust enough to detect it.

Al-Rawi et al (1982) demonstrated an association between uterine prolapse and joint hypermobility using the Beighton score to assess 76 females with prolapse and an equal number of controls.[135] The patients studied by Al-Rawi were younger than the participants of this study (the mean age was 41.3 years and 47% were less than 40 years). Although younger patients were included in the current study the mean age of the group was 58 years. Joint mobility decreases with ageing and this may affect the

accuracy of the Beighton score as an assessment tool. For this reason the Hakim and Grahame screening questionnaire [148] was introduced to detect a history of previous joint hypermobility in patients greater than 50 years of age. Although the screening questionnaire was able to detect joint mobility in 8 subjects with normal Beighton scores the screening tool results did not correlate positively with PD. The sensitivity of the screening questionnaire for detecting joint hypermobility is 80 to 85% [148] but difficulties with recall may limit the use of this self-reported tool in this type of patient group.

Joint mobility is also influenced by geographical location and race.[43] The Beighton score was first developed for use in a South African population in the 1970s.[133] The participants of the Al-Rawi study were Iraqi women, 66% of the prolapse group had hypermobile joints but 18% of the control group was also hypermobile. This reflects the high prevalence of joint hypermobility in this country. The mean Beighton score in the current study was 0 and the highest score achieved in the group was 6, this may be a reflection of a lower prevalence of joint hypermobility in the Western population.

The screening questionnaire and Beighton score assess the mobility of a small group of joints only; hypermobility may be present in joints that have not been formally evaluated. Joint hypermobility is a confirmed manifestation of generalised connective tissue abnormality and it is relatively easy to measure but it is possible to have significant connective tissue pathology without having joint hypermobility as a major feature. The diagnosis of Benign Joint Hypermobility Syndrome can be made even

when only one joint is hypermobile if other characteristics are present.[131] This study did not include other assessments such as the Brighton criteria [131] which may have been able to identify patients with abnormal connective tissue but seemingly normal joint mobility.

The positive effect of oestrogen on joint mobility is well documented.[43] In this group 72.9% of the participants were post-menopausal. Joint mobility assessment may not be the most accurate method of detecting connective tissue abnormality in an older post-menopausal population.

Interestingly, the subjects in this study with joint hypermobility (as defined by a Beighton score of greater than 4) did not have more PD than those patients with normal joint mobility; however they did have less descent at rest. The concept of "fixed increased PD" [84] refers to a stretched and floppy perineum seen in older patients. The perineum sags below the level of the bony outlet at rest but is unable to descend further with effort. The patients with normal joint mobility had a mean resting descent which was 0.75cm below that of the hypermobile group. The normal mobility subgroup is comprised of older subjects and so the effect of ageing and hormonal changes may have contributed to a loss of elasticity and hence produced the descent at rest. However, the descent then achieved on straining is similar to that of the joint hypermobility group therefore the greater PD at rest in the patients with normal mobility cannot be explained by the fixed increased PD theory. A difference in the tissue elasticity of the

hypermobile patients may account for the ability of the perineum to descend but then recoil to a higher starting position.

The subjects with the greatest degree of PD (greater than 1.5cm) were more likely to present with chronic constipation than those with less than 1.5cm of PD (70% versus 3.3%). This is relevant as PD has long been associated with the habit of chronic straining. Parks first postulated that excessive straining was the major causative factor in the development of PD in 1966.[52] Goei et al (1990) [68] and Savoye et al (2003) [69] did not find any association between presenting symptoms and PD measured using proctography but in the former work the sample size was small (19 patients with constipation) and the latter was a study of geriatric patients, the majority of whom had mixed complaints rather than constipation in isolation. In 1999 Harewood et al found that 97% of patients diagnosed with the "Descending Perineum Syndrome" in their unit over a ten-year period predominantly had symptoms of constipation.[70] Multiparity was also a feature associated with PD in this group.

Vaginal delivery is thought to cause PD through stretching of the perineal tissues but in the current study parity was negatively associated with PD. Nulliparous women comprised 13% of the study group (n=9). The mean PD measured in the nulliparous subjects was significantly greater than that of the parous women. This can not be explained by the contribution of joint hypermobility as there was no difference in Beighton scores between the two subgroups. In view of the findings noted above regarding clinical pathology it may be suggested that the nulliparous women have more

descent because of straining due to constipation but there was also no significant difference in the frequency of constipation between the two groups. It may be the case that these nulliparous women do have an underlying connective tissue abnormality but it has not been identified using the Beighton score to detect joint hypermobility. It may also be the case that this small subgroup of women has another contributing factor that is yet to be identified. The effects of parity and gender were removed in the study by Marshman (1987) [174] of mainly male patients who had undergone repair of rectal prolapse. Joint mobility was evaluated by measuring movement of the fifth finger only. The patients with rectal prolapse had more mobility in this joint than a group of age and sex-matched controls. Again this work looked at prolapse rather than PD but it is possible that a similar abnormality of connective tissue is involved in the development of pelvic floor disorders in both men and nulliparous women.

An ideal population for this study would have included patients with connective tissue diseases. If patients with known connective tissue abnormalities were found to have greater degrees of PD than subjects without these diagnoses it would confirm the role of connective tissue abnormality in the aetiology of PD. Further more, measurements could be compared between subgroups of patients with Marfans syndrome, Ehlers Danlos syndrome and BJHS and this might provide information about the specific collagen or elastin abnormality which is associated with PD. This was not possible in the current work because of time constraints due to delays incurred gaining ethical approval. These conditions are uncommon (and in the case of BJHS often under diagnosed), only a small number of patients will present via general Rheumatology

outpatient clinics and most will be seen at specialist centres (for example the Ehlers Danlos Syndrome national diagnostic service based at Sheffield Children's Hospital and the North West London Hospitals trust) therefore a considerable recruitment period would be necessary to achieve adequate numbers. This is, however, an area that could be developed in future research work.

This work has not shown a correlation between PD and joint hypermobility. It is important to recognise that the number of subjects in this study was small and that several variables were compared with the three parameters of PD measurement. This means that any correlations found cannot be seen as conclusive, however, this study has identified a small subgroup of nulliparous women who present at a younger age and have more PD than older parous women. This may suggest that these women are subject to a different pathophysiological process.

The Beighton score was developed forty years ago to assess joint mobility in African subjects; it may not be the appropriate tool to identify connective tissue abnormalities in an older, female, Western population. Although the mean Beighton score of the group as a whole was low it is possible that it is higher than that of the population without PD and clinical symptoms of pelvic floor dysfunction. This could be evaluated in future work by expanding the study to include age and parity matched controls without pelvic floor disorders and patients with known connective tissue diseases. In addition to increasing the number of nulliparous women studied other methods of identifying connective tissue abnormality could be incorporated including the Brighton criteria

[131] and histological examination of tissue samples. Confirmation of the role of connective tissue abnormality in the disease process of this subgroup of patients would have clinical implications in terms of treatment choice and intervention to prevent further damage through obstetric trauma.

Summary

This study shows that PD is a feature of chronic constipation, which supports the theory that excessive straining at stool leads to stretching of the connective tissues of the pelvic floor.

There is no correlation between PD and joint hypermobility as assessed using the Beighton score. Young nulliparous women have the greatest degree of PD and in the absence of other contributing factors it is possible that connective tissue abnormality has played a role in their disease process although the Beighton score may not be a sensitive enough tool to detect it in this population.

Chapter 4. The relationship between perineal descent and other proctographic findings in patients with pelvic floor dysfunction

4.1 Aim

The aim of this study was to determine the significance of PD in relation to other signs of pelvic floor injury including rectocele formation, rectal intussusception and rectal prolapse.

4.2 Patients

Radiology department records were used to generate a list of patients who had been investigated with a defaecating proctogram examination in the two-year time period of July 2009 to July 2011. All of the patients were under the care of the Pelvic Floor Unit at the University Hospital of South Manchester and the examinations were requested to investigate the symptoms of rectal prolapse, difficult defaecation or faecal incontinence. Male patients were excluded because the number of men investigated during this period was very small and therefore would not be adequate to perform a subgroup analysis.

4.3 Methods

The researcher was blinded to the clinical history of the patients during examination of the proctographic images. Following completion of the measurements the proctogram request card was reviewed in order to document the presenting clinical problem. The same RA 1000 Radiology department computer monitor was used to view all examinations. Each proctogram recording was viewed in its entirety before being

replayed so that the relevant images could be frozen and the measurements made. The following findings were recorded; anorectal angle, perineal position at rest, level of the perineum on lifting the pelvic floor, PD on maximum strain (before the anal canal opens), PD on defaecation (at the point of opening of the anal canal), overall PD (PD on straining – PD at rest), presence of rectocele, anterior-posterior depth of rectocele (in centimetres), presence and grade of rectal intussusception or rectal prolapse and presence of other pathology e.g. enterocele, sigmoidocele or lateral rectocele.

4.3.1 Anorectal angle

The "posterior" method was used to define the anorectal angle, this is the angle between the longitudinal axis of the anal canal and a line drawn parallel to the distal half of the posterior rectal wall. See figure 23 chapter 2.

4.3.2 Perineal descent measurement

PD measurements were made using the technique described above (chapter 2). For consistency the image of maximum strain immediately prior to the opening of the upper anal canal was used to measure PD on straining. A measurement was also taken at the beginning of defaecation as the upper anal canal opened and, on maximum lift of the pelvic floor.

4.3.3 Rectocele measurement

A rectocele is the forward bulge of the anterior rectal wall which can be present at rest or on straining. It may increase in size or efface with the strain effort. It is difficult to measure the size of a rectocele using two dimensional imaging. In this study the depth of the rectocele was measured on the image of maximum straining in the anterior-posterior dimension. A vertical line was drawn parallel to the posterior anorectal angle, a perpendicular line was drawn horizontally from this point to the apex of the rectocele anteriorly. See figure 41.

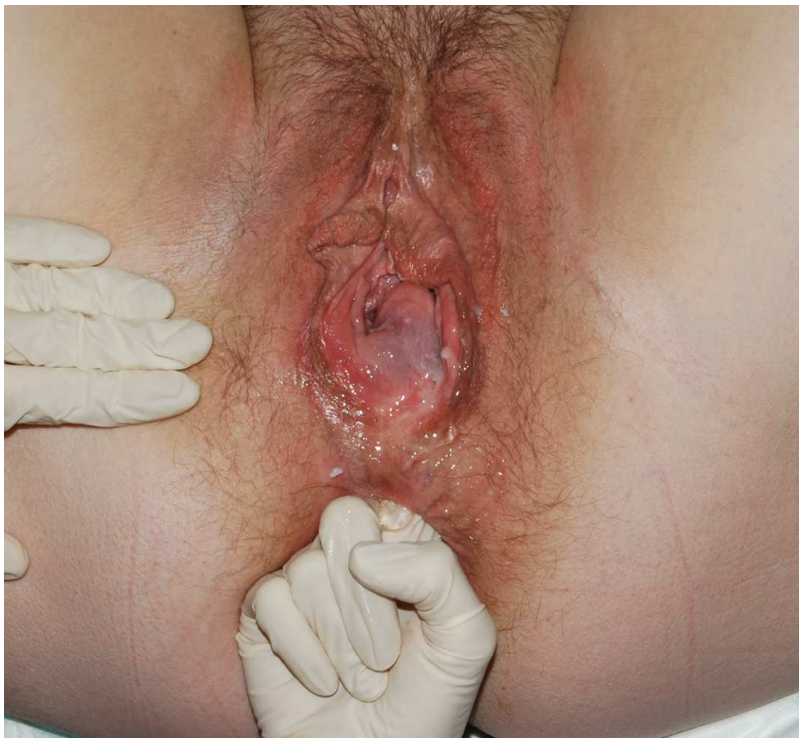


Figure 40. Rectocele demonstrated in the lithotomy position

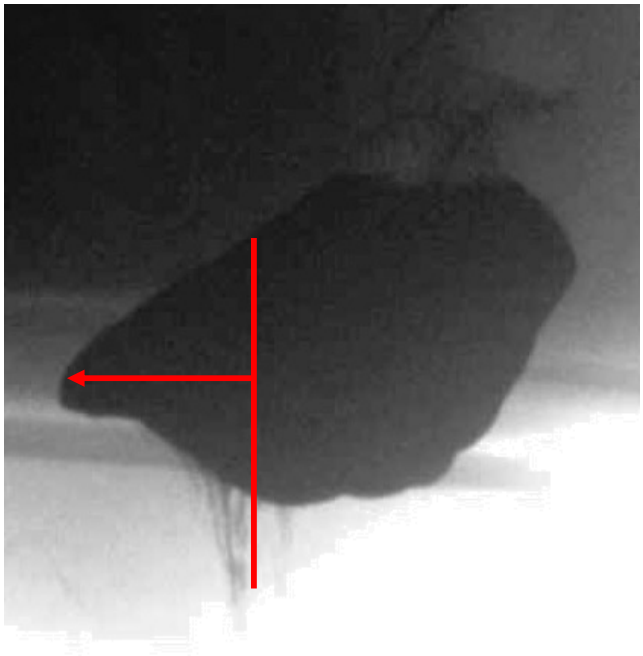


Figure 41. Measurement of rectocele on proctographic image

4.3.4 Rectal intussusception (RI) and rectal prolapse

Intra-rectal intussusception is defined as the in folding of the rectal wall into the lumen of the rectum or in more advanced cases, into the anal canal. It is also known as an internal or occult rectal prolapse and it is recognisable as a funnel-shaped configuration of the rectum seen at the end of evacuation. The degree of intussusception was graded using the Oxford radiological grading of rectal prolapse system.[96] If low grade intussusception was present in the absence of a rectocele it was assigned a grade of I or II depending on whether the lead point was judged by the observer to lie in either the upper or lower part of the rectum.

Grade of Rectal Prolapse	Radiological Features
Intra-Rectal	
I	Descends to proximal limit of rectocele
II	Descends into level of rectocele
Intra-Anal	
III	Descends onto anal sphincter / anal canal
IV	Descends into anal sphincter / anal canal
Rectal Prolapse	
V	Protrudes from anus

Figure 42. The Oxford radiological grading of rectal prolapse system [96]

4.3.5 Enterocele and lateral rectocele

An enterocele is present when loops of small intestine descend into the pelvis anterior to the rectum on straining. During proctography this is seen as a widening of the space between the vagina and the rectum. A lateral rectocele is the bulging of the rectal wall laterally.

4.3.6 Data analysis

Data analysis was performed using SPSS® for Windows version 16.0 (SPSS Inc, Chicago, IL). Correlation coefficients were used to look for a positive relationship between degree of PD and rectocele size and degree of PD and grade of RI. The independent samples t test was used to compare the mean PD measurements in patients with and without the other proctographic findings. The reproducibility and repeatability of the proctographic measurement techniques was assessed using a Bland Altman analysis.

4.4 Results

The proctograms of 323 female patients were reviewed. The mean age of the group was 55 years (range, 18-85 years).

The most common presenting problem was difficult defaecation (38.1 %). Two concurrent clinical complaints were present in 57 patients. Difficult defaecation and faecal incontinence and, difficult defaecation and the presence of rectocele on examination were the two most likely combinations (15 cases of each).

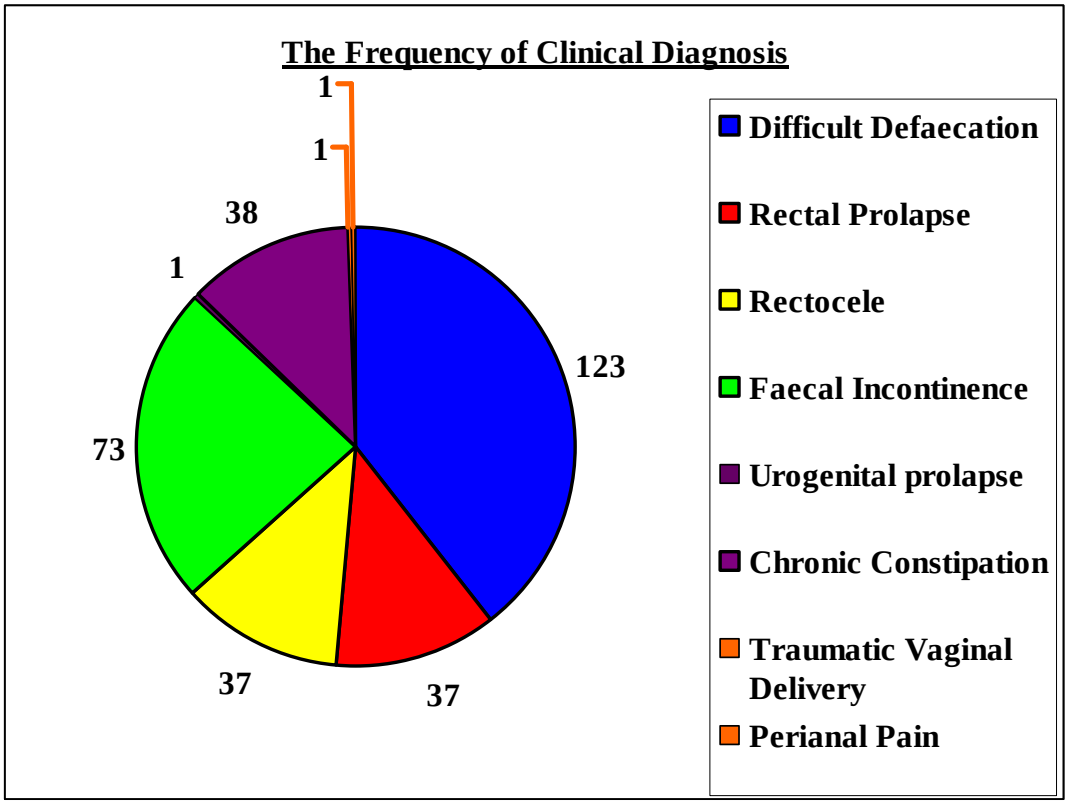


Figure 43. The number of patients with each clinical diagnosis
****presenting complaint unknown in 12 cases***

4.5.1 Perineal descent measurements

PD is the vertical distance traversed by the perineum between the resting state and the strain effort. The mean PD was 1.02cm, SD 0.95 (range, 0-3.15cm). See table 16.

Thirteen patients were unable to perform a pelvic floor lift (4%) and 52 patients (16%) were unable to evacuate the contrast therefore measurements of lift and defaecation were not possible in these cases. The maximum range of movement of the pelvic floor is equal to the sum of the distance between PD at rest and perineal lift, and the distance between PD at rest and PD on defaecation. This measurement was calculated for the 264 patients who were able to lift the perineum and evacuate the contrast. The mean maximum pelvic floor movement was 2.36cm, SD 1cm (range, 0.55-5.5cm).

Table 16 . Mean perineal descent measurements

PD parameters	Measurements in cm
PD at rest	0.08 ± 0.93
Perineal lift	1.11 ± 0.60
PD on straining	-0.93 ± 0.97
PD on defaecation	-1.28 ± 0.95
Overall PD (PD on Strain – PD Rest)	1.02 ± 0.67
Maximum Pelvic Floor Movement	2.36 ± 1.00

Data are means ± SD measured using proctography

4.5.2 The relationship between perineal descent and rectocele formation

The formation of a rectocele was demonstrated in 284 patients (87.9%). The rectocele size ranged from 0.60 to 4.65cm. See table 17.

Table 17. Number of patients with each size of rectocele

Size of Rectocele	<2cm	2-4cm	>4cm
Number of cases (n=284)	155	127	2

A Pearson's correlation coefficient shows a weakly positive relationship between PD and rectocele size (correlation coefficient 0.14, p= 0.02) which is statistically significant at the p=<0.05 level. There was no correlation between maximum movement of the pelvic floor and rectocele size (correlation coefficient 0.06, p=0.38).

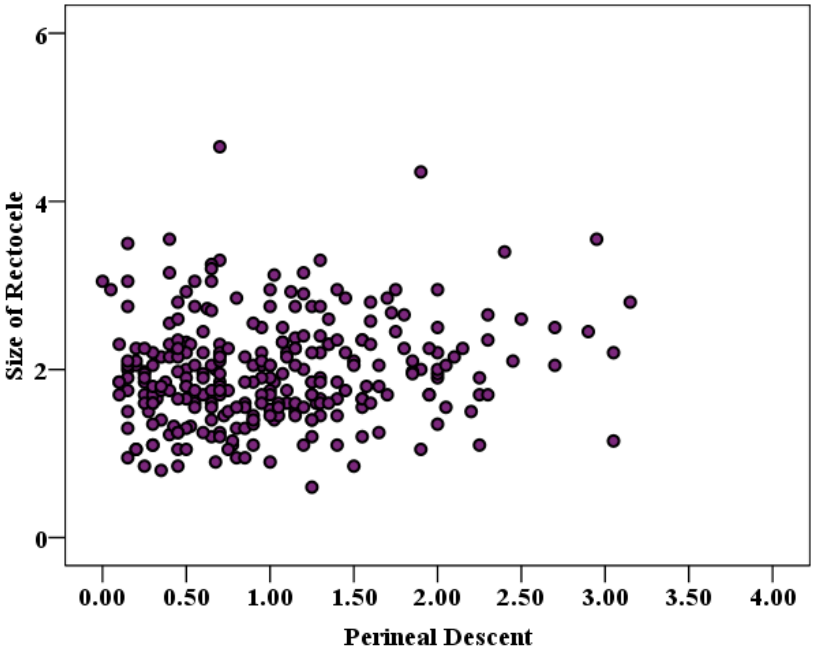


Figure 44. Scatter plot showing a weakly positive correlation between perineal descent and rectocele size in 284 female patients

The patients were divided into four groups according to rectocele size (39 patients did not have a rectocele). The mean PD increases as rectocele size increases, however, the mean PD of the group without a rectocele is 1.05cm and this is both greater than that of the group with a rectocele that is less than 2cm (0.92cm) and similar to the mean PD of

the entire group of patients with a rectocele of any size (1.01cm). Therefore there is no significant difference in mean PD between the patients with and without a rectocele (compared using an independent samples t test, p = 0.72).

Table 18. Mean perineal descent measurements for patients grouped according to rectocele size

Rectocele size (cm)	Mean PD (cm)
Nil (n=39)	1.05 ± 0.79 (0 to 2.80)
<2 (n=155)	0.92 ± 0.57 (0.10 to 3.05)
2-4 (n=127)	1.12 ± 0.73 (0 to 3.15)
>4 (n=2)	1.30 ± 0.85 (0.70 to 1.90)

Data are mean perineal descent measurements ± SD and (range) of 323 female patients

4.5.3 The relationship between PD and RI / rectal prolapse

A degree of RI was present in 119 cases (36.8%). The most frequent grade of intussusception was II. See table 19. A full rectal prolapse occurred in 10 cases (3.1%).

Table 19. Number of patients with each grade of rectal intussusception

Grade	I	II	III	IV	V (rectal prolapse)
Number of patients (n=129)	8	58	18	35	10

There was no correlation between PD and grade of RI (Spearman rank correlation coefficient -0.02, p=0.85).

In this study 71 patients had greater than 1.5cm of PD and 252 patients had less than 1.5cm of descent. The ten patients with rectal prolapse were distributed evenly between these two groups (five cases in each) but as 7% of the group with PD greater than 1.5cm had a rectal prolapse compared to 2% of the group with PD less than 1.5cm this equates to a significantly higher incidence of prolapse in the group with greater PD (compared using chi-square test, p= 0.03).

There was no statistically significant difference between the mean PD in patients with or without a degree of RI (compared using independent t test, p=0.90). Excluding patients with a full rectal prolapse the most PD was seen in patients with low grade (I and II) or no intussusception. See table 20.

Table 20. Mean perineal descent measurements for patients grouped according to grade of rectal intussusception

Grade of RI	Mean PD (cm)
Nil (n=194)	1.01 ± 0.67 (0 to 3.15)
I (n=8)	1.13 ± 0.56 (0.45 to 1.90)
II (n=58)	1.01 ± 0.67 (0.10 to 2.70)
III (n=18)	0.94 ± 0.65 (0.15 to 2.30)
IV (n=35)	0.95 ± 0.65 (0.10 to 3.05)
V (n=10)	1.36 ± 0.83 (0.25 to 2.55)

Data are mean perineal descent measurements ± SD and (range) of 323 female patients

4.5.4 The relationship between rectocele formation and RI

In this study patients were more likely to have a rectocele in isolation than in combination with RI or prolapse. When the two findings where present together the intussusception was more commonly of low grade.

Table 21. Number of patients with rectocele and each grade of rectal intussusception

	Grade of RI			
	Nil	Low grade I+II	High grade III+IV	Prolapse V
Number of cases of rectocele (n=284)	171	63	45	5

The mean rectocele size was not greater in those patients with high grade intussusception or rectal prolapse. There was no significant difference in rectocele size between patients with and without intussusception or prolapse (compared using independent samples t test, p=0.34). The largest rectoceles were present in those patients with grade I and II intussusception. See table 22.

Table 22. Mean rectocele size measurements for patients grouped according to grade of rectal intussusception

Grade of RI	Mean size of rectocele (cm)
Nil (n=171)	1.94 ± 0.65 (0.85 to 4.65)
I (n=7)	2.30 ± 0.53 (1.70 to 3.25)
II (n=56)	2.12 ± 0.61 (0.60 to 3.55)
III (n=16)	1.93 ± 0.39 (1.40 to 2.92)
IV (n=29)	1.81 ± 0.57 (0.80 to 2.75)
V (n=5)	1.85 ± 0.32 (1.60 to 2.35)

Data are mean rectocele size ± SD and (range) in 284 female patients with rectocele

4.5.5 Frequency of enterocele and lateral rectocele

An enterocele was present in 42 cases, the mean age of these patients was 59 years. Approximately half of this group (47.6%) also had RI, the most frequent grade was II (9 cases). The presence of a rectocele in combination with an enterocele was more common with 36 patients (85.7%) having both findings. There was no statistical difference in rectocele size (compared using independent samples t test, p=0.68) or PD (compared using independent samples t test, p=0.47) between patients with and without enterocele.

Table 23. Number of patients with enterocele and each grade of rectal intussusception

	Grade of RI					
	Nil (n=194)	I (n=8)	II (n=58)	III (n=18)	IV (n=35)	V (n=10)
Number of cases of enterocele (n=42)	23 (11.9%)	0	8 (13.8%)	2 (11.1%)	7 (20%)	2 (20%)

A lateral rectocele was present in 21 patients all of whom also had an anterior rectocele. One third of these patients also had a degree of RI and again, the most commonly found grade was II. A higher incidence of larger rectoceles was not found in the group with lateral rectoceles but there was a significantly greater degree of PD in the lateral rectocele group compared to those patients without a lateral rectocele (1.31cm versus 0.99 cm compared using independent samples t test, p=0.03).

4.5.6 Repeatability of proctographic measurement technique

For the above measurements to be considered reliable it was necessary to demonstrate the accuracy of the measurement techniques therefore the proctograms of 54 randomly selected patients were re-examined and the measurements were repeated on a second occasion by the same blinded researcher.

A Bland Altman analysis was used to calculate the mean bias of variation and the 95% limits of agreement between the measurements taken on two separate occasions. A range of agreement was defined as the mean bias ± two standard deviations.

Table 24. The mean bias and 95% limits of agreement for repeatability measurements

Parameter	Mean bias of variation between measurements 1 and 2 (cm)	95% limits of agreement (cm)
PD at rest	-0.03 ± 0.15	-0.33 to 0.27
PD on straining	0.01 ± 0.22	-0.43 to 0.45
Overall PD	-0.03 ± 0.29	-0.61 to 0.55
Size of rectocele	-0.01 ± 0.22	-0.43 to 0.45
Anorectal angle	3.15 ± 12.30	-21.45 to 27.75

Data are mean bias ± SD and 95% limits of agreement between two sets of measurements taken using 54 proctograms

There was 100% agreement between the two sets of measurements regarding the presence of a rectocele. For the grade of RI/prolapse a kappa measure of agreement was used, this was 0.77 which reflects an acceptably high level of agreement.

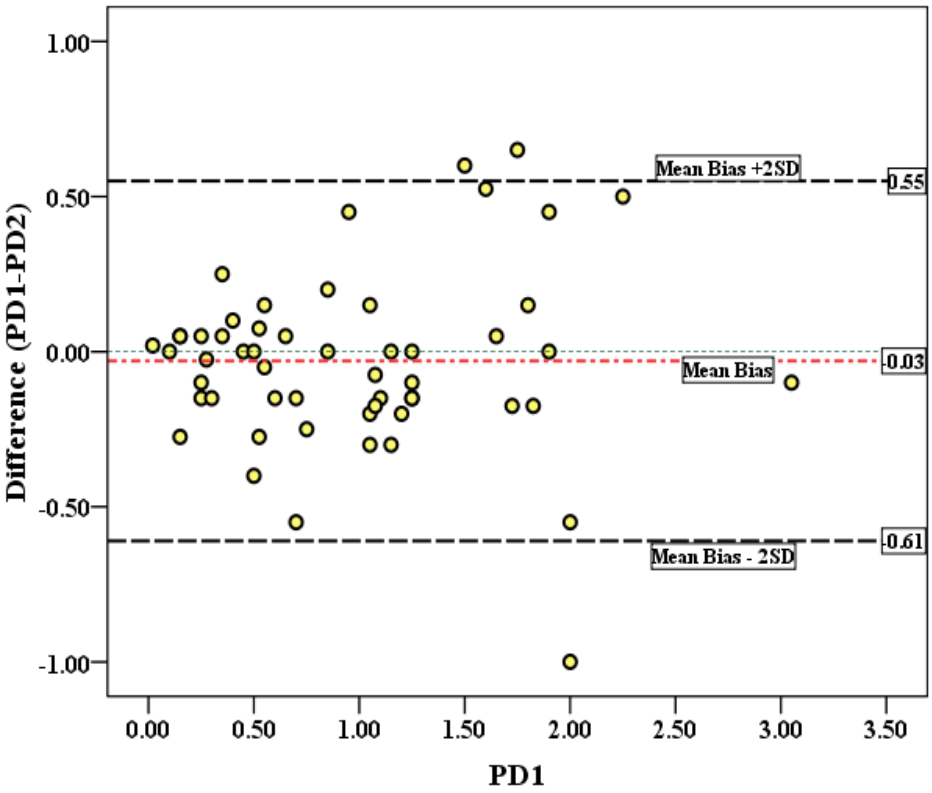


Figure 45. Bland Altman plot of the mean bias (-0.03cm) and 95% limits of agreement between two repeated sets of perineal descent measurements in 54 patients

4.5.7 Reproducibility of proctographic measurement technique

To determine the reproducibility of the measurement techniques employed in this study, a second blinded researcher repeated the measurements on 50 randomly selected proctograms.

Table 25. The mean bias and 95% limits of agreement for reproducibility measurements

Parameter	Mean bias of variation between observers 1 and 2 (cm)	95% limits of agreement (cm)
PD at rest	0.01 ± 0.11	-0.21 to 0.23
PD on straining	0.04 ± 0.33	-0.62 to 0.70
Overall PD	-0.02 ± 0.34	-0.70 to 0.66
Size of rectocele	-0.09 ± 0.30	-0.69 to 0.51
Anorectal angle	-2.90 ± 13.78	-30.46 to 24.66

Data are mean bias ± SD and 95% limits of agreement between measurements taken by two observers using 50 proctograms

There was 100% agreement between the two observers regarding the presence of a rectocele and grade of RI/prolapse.

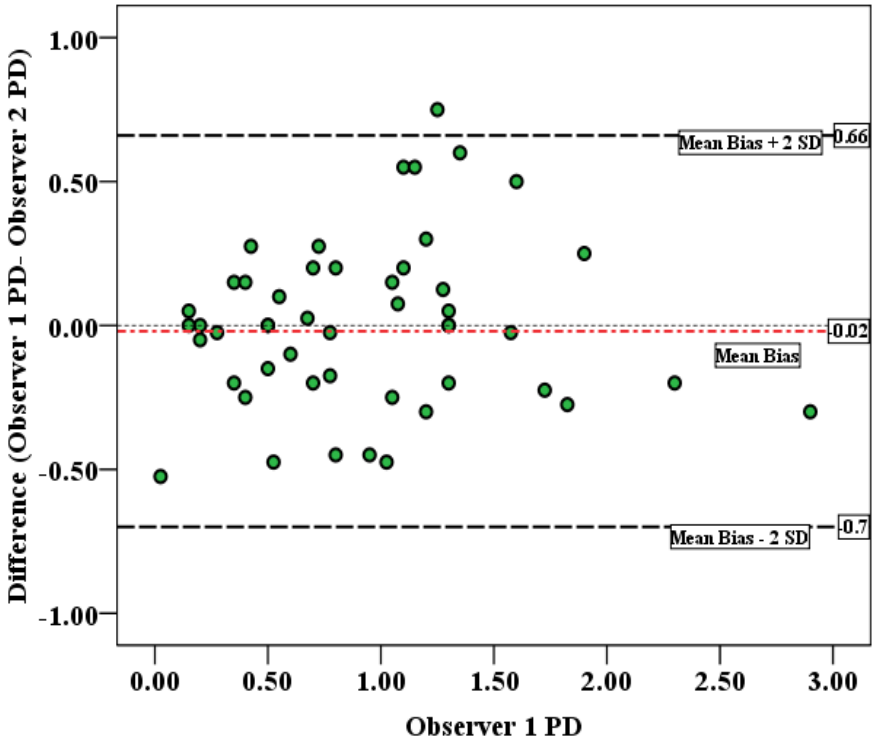


Figure 46. Bland Altman plot of the mean bias (-0.02cm) and 95% limits of agreement between the perineal descent measurements of two observers in 50 patients

4.6 Discussion

The aim of this study was to explore the relationship between PD and other proctographic findings that represent connective tissue stretching of the pelvic floor. If PD is a sign of generalised connective tissue weakness of the pelvic floor and if the same pathophysiological mechanism is involved in the development of all pelvic floor connective tissue injuries we would expect those patients with the greatest PD to also have the largest rectoceles and the highest grade of intussusception or rectal prolapse.

This study did not demonstrate a positive correlation between PD and RI. One interpretation of this is that PD and RI are caused by weakness of different parts of the pelvic support structures. Grade II recto-rectal intussusception was the commonest stage of RI found in this study. This supports Shorvon's theory that some invagination of the rectum during defaecation is physiological and low grade intussusception is a normal finding.[86] Although the numbers were small there was, however, a greater degree of PD found in patients with rectal prolapse. PD may therefore have a causative role in allowing intussusception to progress to external prolapse or it may be the case that prolapse of the rectum leads to further descent of the perineum.

In the literature patients with PD report an increased incidence of prolapse symptoms but not of faecal incontinence or obstructed defaecation which are more commonly associated with intussusception.[70, 71] In 1985 Snooks et al showed that patients with rectal prolapse and faecal incontinence had marked PD unlike those who had faecal incontinence alone.[67] The association of PD with prolapse but not with

intussusception may support the argument that prolapse and intussusception are separate entities rather than a spectrum of the same disease.

Pearson's correlation did show a positive relationship between rectocele size and PD however, this correlation was very weak and the group of 39 patients without a rectocele had a mean PD that was greater than those with a small rectocele. We cannot therefore conclude that PD increases as rectocele size increases. The aetiology of rectocele formation involves damage to the rectovaginal septum, the most common mode of injury is likely to be childbirth. It is possible that a defect in this fascial layer allows the normal downward intra-abdominal forces to be concentrated on this weakened area leading to the formation of a rectocele rather than descent of the perineum as a whole. The presence of a lateral rectocele was associated with greater PD suggesting that either the two entities are caused by the same distribution of forces or that PD contributes to the formation of a lateral rectocele.

There was no relationship between RI and rectocele formation and patients were more likely to have a rectocele in isolation than in combination with RI. The Oxford group found the opposite to be the case (35 of 40 patients with a rectocele also had intussusception).[96] This was a study of patients with faecal incontinence only, the current study is larger and includes patients with prolapse and obstructed defaecation symptoms. The incidence of intussusception in patients with a rectocele was 38% and this is similar to the findings of Thompson et al (2002) who looked at occult intussusception in patients with obstructed defaecation and found the incidence to be

33% in patients with rectoceles.[178] The lower number of rectoceles in isolation in the Oxford study may reflect the aetiological role of intussusception in faecal incontinence (possibly through a pressure effect on the internal anal sphincter) especially in combination with a rectocele. The lack of a positive relationship between RI and rectocele formation again suggests that different supporting structures are affected in the development of each condition.

The method used for rectocele measurement in this work differed from that used by the Oxford group.[96] The depth of the rectocele was measured on the image of maximum straining in the anterior-posterior dimension. A vertical line was drawn parallel to the posterior anorectal angle, a perpendicular line was drawn horizontally from this point to the apex of the rectocele anteriorly. The usual method comprises a vertical measurement from the estimated point of where the "normal" anterior wall of the rectum should lie to the apex of the rectocele. A senior Radiologist was consulted in devising this method and it was felt that it would provide a more consistent and easily reproducible measurement, however, by incorporating a new way of measuring rectocele size into this study it does limit comparison with other work.

In agreement with the work of Mellgren in 1994, half of the patients with an enterocele in the current study also had intussusception.[98] There was no association between enterocele formation and PD but 85.7% of the patients with an enterocele also had a rectocele. The presence of an enterocele is considered by some groups to be a marker of severe pelvic floor weakness.[179] In the study by Jarrett et al enterocele was associated

with increasing grade of RI.[179] This was also the case in the current work; 13.8% of the patients with a grade II RI had an enterocele compared to 20% each of those with grade IV RI and full rectal prolapse. This association between RI and enterocele suggests the presence of a shared mechanism of development. If enterocele formation is a sign of severe damage to the pelvic organ support system then it would seem likely that rectovaginal fascial injury has also occurred in these patients explaining the strong association between enterocele and rectocele in this group.

The intra-rater repeatability of the proctographic measurement techniques was assessed by the same observer repeating the measurements in 54 cases on a second occasion. For rectocele size and each parameter of PD the mean bias of variation between the two sets of measurements was clinically acceptable at less than one millimetre. There was 100% agreement on the presence of a rectocele. In this group 22 patients had RI, in two cases the intussusception was not noted on one of the measurements. In 16 cases there was agreement on the stage of the RI (72.7%, Kappa value 0.77).

The inter-rater reliability of the technique was assessed using a second examiner to repeat the measurements in 50 cases. Again using a Bland Altman analysis the mean bias of variation between measurements of rectocele size and all parameters of PD was acceptable at less than one millimetre. There was complete agreement on the presence of a rectocele and the presence and grade of rectal intussusception. The improved agreement regarding RI grade in this study is likely to be a reflection of the learning curve of the first observer.

Of all the parameters measured the greatest variability was seen in the estimation of the anorectal angle. See table 25. The posterior method of measuring the angle was used in both the repeatability and reproducibility studies. It was necessary to identify the anorectal angle in order to use this to represent the level of the pelvic floor but the actual value of the angle was not important in this study. The accuracy of measuring the angle could be improved by using the computer software measuring device rather than a visual estimation by the observer.

The mean PD measured in this group of 323 symptomatic patients was 1.02cm (range, 0-3.15cm). This is less than that observed in previous smaller studies (Oettle, 2.9cm and Henry, 3.2cm).[62, 72] This may be due to several factors. The current study utilised the top of the commode seat as a consistent landmark rather than the pubococcygeal line, to include these bony landmarks a wider field is required and this produces glare and increased exposure to radiation. The commode seat relates to the level of the ischial spines which provides consistency with the mechanical measurements used in other parts of this work (chapter 2). A magnification factor was applied in the current study to compensate for the magnification produced by fluoroscopy, this was not the case in the work by Henry. Again to provide consistency with the other parts of this study, PD on straining was measured at the point of maximum descent of the anorectal angle before the upper anal canal opened. It is possible that in other studies descent on straining was measured at a later stage in the evacuation process thus showing a greater degree of descent.

Using the pubococcygeal line as a reference PD of greater than 3cm was originally deemed to be abnormal.[66] A degree of PD is part of the normal defaecatory process and there is wide variability in proctographic techniques and methods of PD measurement. It is therefore not possible to establish what degree of PD is normal or abnormal for any particular individual.

This group of 323 women presented with symptoms of obstructed defaecation, faecal incontinence or rectal prolapse and were felt to require a proctogram for further investigation by their examining clinician as such they are representative of a range of patients with pelvic floor disorders however they are not a randomly selected sample. The presenting symptoms were taken from the proctogram request cards rather than from interviewing the patients themselves therefore the accuracy of this clinical information was not validated. Men were not included as the number presenting with these problems in the study period was too low to allow an accurate subgroup analysis. Patients with a clinically obvious rectal prolapse at presentation will often proceed straight to surgical intervention without proctography hence the low number of patients with an external rectal prolapse found in this study. There is a bias towards younger and more physically fit participants because proctography is not usually requested for the very elderly or frail patients who are unlikely to tolerate the examination. There is also a degree of self-selection as some patients will choose not too attend for the investigation.

Summary

The methods used to measure PD, rectocele size and grade of RI and rectal prolapse using defaecating proctography were assessed and found to be repeatable and reproducible, consequently these methods could be used accurately in future studies.

The relationship between PD and other connective tissue injuries of the pelvic floor is complex. PD is positively associated with the presence of rectal prolapse and lateral rectocele formation, however, an individual can have an enterocele, a large rectocele or a high grade of RI with less PD than patients without these findings. A rectocele occurs when there is damage to the rectovaginal septum, prolapse of the rectum occurs when the organ support structures are stretched and PD may develop because of weakening of the pelvic floor connective tissues. Although trauma to the pelvic floor support structures is common to the pathophysiology of all of these conditions the exact anatomical site of injury and thus the distribution of the downward intra-abdominal pressure is likely to determine the nature of the injury that predominates.

Chapter 5. The relationship between clinical symptoms and proctographic findings in patients with pelvic floor dysfunction

5.1 Aim

Connective tissue injuries of the pelvic floor are commonly found during defaecating proctography examinations of patients with pelvic floor dysfunction but these findings have also been noted on the examinations of asymptomatic individuals. Disorders of the pelvic floor are not life-threatening but the morbidity associated with these conditions can have a major detrimental effect on quality of life. As corrective surgery may be offered to treat these conditions a better understanding of the symptoms caused by them may help to guide clinical practice. The aim of this study was to identify which clinical symptoms are associated with the presence of pelvic floor disorders demonstrated using defaecating proctography.

5.2 Patients

For the previous study (chapter 4) Radiology department records at the University Hospital of South Manchester were used to generate a list of patients with pelvic floor disorders who had been investigated with a defaecating proctogram in the two-year time period of July 2009 to July 2011. The same patients were included in the current study, male patients were again excluded because the number of men investigated during this period was very small and therefore would not be adequate to perform a subgroup analysis.

5.3 Methods

The defaecating proctograms were reviewed as part of the previous study (4.3 Methods). The measurements of PD, presence and size of rectocele, grade of RI or prolapse and presence of enterocele or lateral rectocele were recorded in an Excel database. The patients who had been investigated with proctography were contacted by post and invited to complete the short form of the Pelvic Floor Distress Inventory questionnaire (PFDI-20 see appendix 4). The questionnaire is comprised of 20 questions which assess the presence of urinary, anorectal and pelvic organ prolapse symptoms and the amount of "bother" they cause. If a symptom is present the patient is asked to grade the impact of it using a scale of 1 to 4 (1 = never causes bother, 4 = quite a bit of bother).

5.3.1 Data analysis

Data analysis was performed using SPSS® for Windows version 16.0 (SPSS Inc, Chicago, IL). The presence of each proctographic finding was correlated with each symptom score using the chi-square test.

5.4 Results

Questionnaires were distributed to 288 female patients who had been investigated with proctography between July 2009 and July 2011. The questionnaires were completed and returned by 178 patients (61.8%). The group that returned the questionnaires were significantly older than the group that did not reply (56.6 years versus 52.2 years, compared using independent samples t test p= 0.01). The two groups did not vary statistically in terms of mean PD, rectocele size, presence of intussusception and prolapse or presenting clinical problem.

Table 26. Distribution of clinical problems

Clinical problem	Frequency of cases	
	Questionnaire completed (n=178)	Questionnaire not completed (n=110)
Difficult defaecation	63	45
Rectal prolapse	20	12
Rectocele	21	11
Faecal incontinence	46	20
Urogenital prolapse	0	1
Chronic constipation	19	16
Perineal trauma	0	1
Perineal pain	1	0
Unknown	8	4

Table 27. Mean perineal descent and rectocele size measurements

	Responders (n=178)	Non-responders (n=110)	P value
Perineal descent (cm)	0.96 ± 0.63 (0 to 3.05)	1.08 ± 0.65 (0.10 to 3.15)	0.10
Rectocele size (cm)	1.93 ± 0.59 (0.60 to 3.55)	1.94 ± 0.61 (0.85 to 4.35)	0.93

Data are means ±SD and (range), means compared using independent samples t test

Table 28. Incidence of rectal intussusception and rectal prolapse

	Frequency of cases		
	Responders (n=178)	Non-responders (n=110)	P value
Rectal intussusception / prolapse	69	43	0.93

Data are number of cases with rectal intussusception or rectal prolapse, compared using chi-square test

5.4.1 Surgical history

An addendum was added to the questionnaire for the patient to include the nature and date of any bladder, bowel or pelvic floor surgery they had undergone. Following investigation with proctography some patients went on to have corrective surgery, 45 of the 178 responders completed the questionnaire after having an operation. In this group the questionnaire results reflect the effects of surgery rather than the symptoms potentially caused by the proctographic findings and therefore these 45 questionnaires were excluded from the study. Of the remaining 133 patients 88 had never had surgery, 34 had undergone pelvic floor surgery some years prior to presenting for investigation on this occasion and 11 went on to have an operation after proctography but completed the questionnaire based on their pre-operative symptoms.

The questionnaire scores were dichotomised; a positive response was defined as the presence of the symptom plus a score of 2 to 4 on the impact scale. A negative response was defined as the presence of the symptom with an impact score of one only (it does not bother the patient at all) or the absence of the symptom. Questions that were not answered by an individual participant were omitted.

For each of the 20 questions the participants were divided into two groups based on either a positive or negative response to the question. A chi-square test was used to determine a difference in the incidence of the proctographic findings between the two groups. The following proctographic findings were correlated with each question; PD greater than 1.5cm, presence and size of rectocele, RI, rectal prolapse, enterocele and lateral rectocele. See appendix 5.

Table 29. Number of patients with each proctographic finding

Proctographic finding	Number of cases (n=133)	Percentage of total %
Perineal descent >1.5cm	26	19.5
Rectocele	117	88
Rectocele >2cm	50	37.6
Rectal intussusception	49	36.8
RI Grade I	1	0.8
RI Grade II	20	15
RI Grade III	9	18.1
RI Grade IV	16	12
Rectal prolapse	3	2.3
Enterocele	17	12.8
Lateral rectocele	8	6

5.4.2 Symptoms of pelvic organ prolapse

Table 30. Questions relating to pelvic organ prolapse

Question Number	Question
1	Do you usually experience pressure in the lower abdomen?
2	Do you usually experience heaviness or dullness in the lower abdomen?
3	Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?
14	Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?
20	Do you experience pain or discomfort in the lower abdomen or genital region?

The presence of a rectocele greater than 2cm in size was associated with a bulge that could be seen or felt in the vagina.

Table 31 Correlation of question 3 and rectocele size

Q3 Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?			Rectocele size (cm)		
			rectocele<2	rectocele2-4	Total
Q3	NO OR MINOR SYMPTOMS	Patient number	56	22	78
		%	71.8%	28.2%	100.0%
	CLEAR SYMPTOMS	Patient number	27	28	55
		%	49.1%	50.9%	100.0%
	Total	Patient number	83	50	133
		%	62.4%	37.6%	100.0%

Pearson Chi-square p=0.01*
**significant at p<0.05 level*

Only two of the 47 patients with the symptom of rectal prolapse were found to have proctographic evidence of external rectal prolapse. One of the 83 patients who denied having this symptom had a demonstrable prolapse on proctography. RI was present in 29 of the patients who complained of rectal prolapse but this was not significantly different from the incidence in patients without this symptom.

Table 32. Correlation of question 14 and rectal prolapse

Q14 Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?			Rectal prolapse		
			no prolapse	prolapse	Total
Q14	NO OR MINOR SYMPTOMS	Patient number	82	1	83
		%	98.8%	1.2%	100.0%
	CLEAR SYMPTOMS	Patient number	45	2	47
		%	95.7%	4.3%	100.0%
	Total	Patient number	127	3	130
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.27

Table 33. Correlation of question 14 and rectal intussusception

Q14 Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?			Rectal Intussusception		
			RI	No RI	Total
Q14	NO OR MINOR SYMPTOMS	Patient number	29	53	82
		%	35.4%	64.6%	100.0%
	CLEAR SYMPTOMS	Patient number	16	29	45
		%	35.6%	64.4%	100.0%
	Total	Patient number	45	82	127
		%	35.4%	64.6%	100.0%

Pearson Chi-square p=0.98

The formation of a lateral rectocele was associated with the sensation of rectal prolapse but this difference did not reach statistical significance (10.6% of patients with the symptom versus 2.4% without the symptom, p=0.05). There were no statistically

significant associations between the other proctographic findings and the above symptoms of pelvic organ prolapse.

5.4.3 Symptoms of anorectal dysfunction

Table 34. Questions relating to anorectal dysfunction

Question Number	Question
4	Do you usually have to push on the vagina or around the rectum to have a complete bowel movement?
7	Do you feel you have to strain too hard to have a bowel movement?
8	Do you feel you have not completely emptied your bowels at the end of a bowel movement?
9	Do you usually lose stool beyond your control if your stool is well formed?
10	Do you usually lose stool beyond your control if your stool is loose or liquid?
11	Do you usually lose gas from the rectum beyond your control?
12	Do you usually have pain when you pass your stool?
13	Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?

The use of manual pressure around the vagina or rectum to facilitate defaecation was reported in 89 respondents. There was no statistically significant relationship with any proctographic finding. A rectocele was present in 89.9% of those with the symptom but 85% of those who denied the symptom were also found to have a rectocele (p=0.42).

Straining to defaecate was also a commonly reported symptom (102 positive responses). There was no association with PD greater than 1.5cm, 79 (77.5%) of the patients who strain had less than 1.5cm of PD. There was no difference between the patients who did and did not strain with regards to presence or size of rectocele. Straining was not associated with the presence of RI; only 30.3% of patients who reported straining were

found to have a degree of RI and more than half (53.8%) of those with intussusception did not report the need to strain.

Incomplete evacuation was a bothersome symptom for 121 respondents. It was not associated with any particular proctographic finding. The 10 patients who did not complain of incomplete evacuation were all found to have a rectocele and half of these were greater than 2cm in size.

Incontinence of formed stool was reported by only 53 respondents. RI was present in half of these patients compared to only 26% of those who did not complain of this symptom.

Table 35. Correlation of question 9 and rectal intussusception

Q9 Do you usually lose stool beyond your control if your stool is well formed?			Rectal intussusception		
			RI	No RI	Total
Q9	NO OR MINOR SYMPTOMS	Patient number	19	54	73
		%	26.0%	74.0%	100.0%
	CLEAR SYMPTOMS	Patient number	27	26	53
		%	50.9%	49.1%	100.0%
	Total	Patient number	46	80	126
		%	36.5%	63.5%	100.0%

Pearsons Chi-Square p=0.00*

In the group of 49 patients with RI or rectal prolapse there was a positive linear trend, as the grade of RI increased the likelihood of having incontinence for formed stool also increased.

Table 36. Correlation of question 9 and grade of rectal intussusception

Q9 Do you usually lose stool beyond your control if your stool is well formed?			Grade of Rectal intussusception						
			no RI	1	2	3	4	5	Total
Q9	NO OR MINOR SYMPTOMS	Patient number	54	0	8	3	8	3	76
		%	71.1%	.0%	10.5%	3.9%	10.5%	3.9%	100.0 %
	CLEAR SYMPTOMS	Patient number	26	1	12	6	8	0	53
		%	49.1%	1.9%	22.6%	11.3%	15.1%	.0%	100.0 %
	Total	Patient number	80	1	20	9	16	3	129
		%	62.0%	0.8%	15.5%	7.0%	12.4%	2.3%	100.0 %

Pearsons Chi-Square p=0.04*

Linear-By-Linear Association p=0.10

The number of patients with each grade of RI is small and the positive trend is not statistically significant however a positive relationship between increasing grade of RI and the presence of this symptom can be demonstrated using a Mann Whitney U test (p=0.04).

The symptom of incontinence of liquid stool was also associated with the presence of RI and again a weakly positive trend within the grade of RI was seen.

Table 37. Correlation of question 10 and rectal intussusception

Q10 Do you usually lose stool beyond your control if your stool is loose or liquid?			Rectal intussusception		
			RI	No RI	Total
Q10	NO OR MINOR SYMPTOMS	Patient number	8	36	44
		%	18.2%	81.8%	100.0%
	CLEAR SYMPTOMS	Patient number	38	48	86
		%	44.2%	55.8%	100.0%
	Total	Patient number	46	84	130
		%	35.4%	64.6%	100.0%

Pearson Chi-square p=0.00*

Table 38. Correlation of question 10 and grade of rectal intussusception

Q10 Do you usually lose stool beyond your control if your stool is loose or liquid?			Grade of Rectal intussusception						
			no RI	1	2	3	4	5	Total
Q10	NO OR MINOR SYMPTOMS	Patient number	36	0	4	2	2	1	45
		%	80.0%	.0%	8.9%	4.4%	4.4%	2.2%	100.0 %
	CLEAR SYMPTOMS	Patient number	48	1	16	7	14	2	88
		%	54.5%	1.1%	18.2%	8.0%	15.9%	2.3%	100.0 %
	Total	Patient number	84	1	20	9	16	3	133
		%	63.2%	.8%	15.0%	6.8%	12.0%	2.3%	100.0 %

Pearsons Chi-Square p=0.11

Linear-By-Linear Association p=0.01*

Incontinence of flatus was only significantly associated with the presence of RI. The presence of pain on passing stool was not associated with any proctographic finding.

Table 39. Correlation of question 11 and rectal intussusception

Q11 Do you usually lose gas from the rectum beyond your control?			Rectal intussusception		
			RI	No RI	Total
Q11	NO OR MINOR SYMPTOMS	Patient number	6	26	32
		%	18.8%	81.2%	100.0%
	CLEAR SYMPTOMS	Patient number	40	58	98
		%	40.8%	59.2%	100.0%
	Total	Patient number	46	84	130
		%	35.4%	64.6%	100.0%

Pearson Chi-square p=0.02*

Table 40. Correlation of question 11 and grade of rectal intussusception

Q11 Do you usually lose gas from the rectum beyond your control?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q11	NO OR MINOR SYMPTOMS	Patient number	26	0	3	0	3	0	32
		%	81.2%	.0%	9.4%	.0%	9.4%	.0%	100.0 %
	CLEAR SYMPTOMS	Patient number	58	1	17	9	13	3	101
		%	57.4%	1.0%	16.8%	8.9%	12.9%	3.0%	100.0 %
	Total	Patient number	84	1	20	9	16	3	133
		%	63.2%	0.8%	15.0%	6.8%	12.0%	2.3%	100.0 %

Pearsons Chi-Square p=0.19

Linear-By-Linear Association p=0.03*

Faecal urgency was reported by 86 respondents, 43.4% were found to have a degree of RI compared to 21.3% of those without urgency.

Table 41. Correlation of question 13 and rectal intussusception

Q13 Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?			Rectal intussusception		
			RI	No RI	Total
Q13	NO OR MINOR SYMPTOMS	Patient number	10	37	47
		%	21.3%	78.7%	100.0%
	CLEAR SYMPTOMS	Patient number	39	47	83
		%	43.4%	56.6%	100.0%
	Total	Patient number	46	84	130
		%	35.4%	64.6%	100.0%

Pearson Chi-square p=0.01*

Table 40. Correlation of question 13 and grade of rectal intussusception

Q13 Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q13	NO OR MINOR SYMPTOMS	Patient number	37	1	6	1	2	0	47
		%	78.7%	2.1%	12.8%	2.1%	4.3%	.0%	100.0 %
	CLEAR SYMPTOMS	Patient number	47	0	14	8	14	3	86
		%	54.7%	.0%	16.3%	9.3%	16.3%	3.5%	100.0 %
	Total	Patient number	84	1	20	9	16	3	133
		%	63.2%	0.8%	15.0%	6.8%	12.0%	2.3%	100.0 %

Pearsons Chi-Square p=0.03*

Linear-By-Linear Association p=0.00*

5.4.4 Symptoms of urinary dysfunction

Table 43. Questions relating to urinary dysfunction

Question Number	Question
5	Do you usually experience a feeling of incomplete bladder emptying?
6	Do you ever have to push up in the vaginal area with your fingers to start or complete urination?
15	Do you usually experience frequent urination?
16	Do you usually experience urine leakage associated with a feeling of urgency; that is, a strong sensation of needing to go to the bathroom?
17	Do you usually experience urine leakage related to coughing, sneezing or laughing?
18	Do you usually experience small amounts of urine leakage (drops)?
19	Do you usually experience difficulty emptying your bladder?

Rectocele was a common finding in both patients with and without urine leakage (90% and 85% respectively). In those with urine leakage the rectocele was more likely to be small in size whereas 32 of the 70 patients without the symptom of urine leakage had a rectocele that was greater than 2cm in size.

Table 44. Correlation of question 18 and size of rectocele

Q18 Do you usually experience small amounts of urine leakage (drops)?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q18	NO OR MINOR SYMPTOMS	Patient number	38	32	70
		%	54.3%	45.7%	100.0%
	CLEAR SYMPTOMS	Patient number	43	17	60
		%	71.7%	28.3%	100.0%
	Total	Patient number	81	49	130
		%	62.3%	37.7%	100.0%

Pearsons Chi-square p=0.04*

Linear-By-Linear Association p=0.04*

The only other urinary symptom to show a relationship with a proctographic finding was that of difficulty emptying the bladder, 38 respondents reported the presence of this symptom. There was a positive relationship between the presence of an enterocele and difficulty emptying the bladder, 23.7% of those with clear symptoms had an enterocele compared to only 8.5% of those without symptoms.

Table 45. Correlation of question 19 and presence of enterocele

Q19 Do you usually experience difficulty emptying your bladder?			Enterocele		
			enterocele	no enterocele	Total
Q19	NO OR MINOR SYMPTOMS	Patient number	8	86	94
		%	8.5%	91.5%	100.0%
	CLEAR SYMPTOMS	Patient number	9	29	38
		%	23.7%	76.3%	100.0%
	Total	Patient number	17	115	132
		%	12.9%	87.1%	100.0%

Pearsons Chi-square p=0.02*

5.5 Discussion

The aim of this study was to identify which clinical symptoms were associated with the common pelvic floor abnormalities found on defaecating proctography examinations. The Pelvic Floor Distress Inventory short form questionnaire was completed by 178 women in total, 133 women answered the questions based on their symptoms prior to interventional surgery.

RI was the proctographic finding which was significantly associated with the most clinical symptoms, a degree of intussusception was present in 49 respondents (36.8%). Intussusception was associated with a bothersome degree of the symptoms of incontinence of flatus, incontinence of both formed and liquid stool and faecal urgency. Incontinence may be caused by the pressure effect of the intussusceptum on the internal sphincter but this would only occur in the case of high grade (IV) intussusception and most of the RI seen in this study was low grade (II). Urgency is usually associated with poor external sphincter function, it is difficult to explain the association with RI in this study. It is likely that other unquantified factors have contributed to the development of urgency and incontinence in these patients with RI. Correlation with anal manometry results would clarify this further. A limitation of this study is the lack of additional anorectal physiology studies. There was a positive trend towards an increase in the number of patients with faecal incontinence of formed and liquid stool as the grade of RI increased however the number of patients with each grade of RI was too small for this interpretation to be valid. Straining, often considered to be closely associated with this condition, was not linked to the presence of RI in this study.

Rectocele was the commonest proctographic finding in the study, it was present in 117 subjects (88%). In 50 women the rectocele was greater than 2cm in size. The sensation of a bulge into the vagina was only associated with the presence of a larger rectocele (>2cm), this reinforces the theory that small rectoceles can often be asymptomatic (this was highlighted by the Shorvon et al study of proctography in normal volunteers in 1989).[86] Vaginal digitation is a mechanism employed by many women to empty a rectocele and thus alleviate obstructed defaecation, this study did not show an association with this symptom and the presence of a rectocele. This may represent the reluctance of some women to use this manoeuvre or to admit to using it.

It is not our routine clinical practice to investigate patients diagnosed clinically with an external rectal prolapse with defaecating proctography therefore there were only three patients found to have a rectal prolapse radiologically in this study. Interestingly 47 patients complained of the sensation of prolapse, in 29 of these women this could be explained by the presence of a degree of RI although this was not a statistically significant association. This suggests that the sensation of rectal prolapse is not a sensitive indicator of actual external prolapse and may represent either the presence of other pathologies not measured during this study (such as haemorrhoids or mucosal prolapse) or a neuropathic element which gives rise to this sensation.

The sensation of rectal prolapse was associated with the presence of lateral rectocele although this did not quite reach statistical significance. Lateral rectocele and enterocele were not common proctographic findings (8 and 17 cases respectively). The only

symptom associated with the presence of an enterocele was difficulty emptying the bladder. This could be explained by external pressure of the herniating small bowel loops behind the bladder. As mentioned in the previous chapter (4) an enterocele may be a sign of severe damage to the supporting structures of the pelvic floor therefore the association between enterocele and difficulty emptying the bladder may be a reflection of the weakness of all three compartments of the pelvic floor.

As previously mentioned in chapter 4 these patients were not a random sample, they were included because they were felt to require a defaecating proctogram by their examining surgeon. The PFDI short form questionnaire is a validated tool which has been shown to have good test-retest reliability and as it is shorter in length than the original PFDI it is relatively quick and convenient to complete. The questionnaire was not designed to be an aid to diagnosis, it is used to document symptoms and the impact they have on quality of life. Subjectivity is inevitable in a study which uses self-reported questionnaires, the patient must recall the symptoms that they had at the time of proctography and the accuracy of this recall may be affected by the lapse of time between presentation and completion of the questionnaire. In 11 cases the respondents had undergone interventional surgery but completed the questionnaires with regards to their symptoms prior to their operation. The accuracy of the responses in these cases will depend on the patient's ability to recall their pre-operative symptoms and it may also be influenced by their satisfaction with the results of surgery. The questionnaires were distributed by post and completed by patients in private but the sensitive nature of the

questions may also influence the accuracy of the responses, some patients may not wish to admit to certain symptoms such as vaginal digitation or incontinence.

The PFDI-20 uses a four point scale to grade the impact of a symptom on quality of life. A score of 1 represents a symptom that is present but does not bother the patient at all. In this study the scores were dichotomised so that a score of 1 was grouped with a negative response to the question (i.e. the symptom was not present). This was the case because surgery is only considered when a symptom greatly affects the quality of a patient's life, however , this does influence the interpretation of the results. By including all positive answers to the questions regardless of the symptom impact there may have been a stronger association between certain proctographic findings and symptoms.

We must also consider the possibility of a positive association between symptoms and proctographic findings due to chance when a large number of statistical tests are performed. Using a p value of 0.05 we would expect 1 in 20 (eight) of the tests to be positive by chance. In this study there were 11 statistically significant results. The use of a Bonferroni calculation can be applied to attempt to correct for this (p values are multiplied by the number of tests performed) but as this is an exploratory study without a definitive outcome this calculation has not been performed but the above point is of relevance in interpreting the significance of the findings.

In 1989 Shorvon et al introduced the idea that findings previously thought to be pathological such as RI, PD and rectocele could be present in asymptomatic individuals

including nulliparous women and men.[86] Rectocele measurement and grading of RI were carried out using different methods from the current study but a rectocele was present in 17 of the 21 females and 3 of the 24 males included. RI of grade IV or greater was found in 22 of the 44 subjects. Although this was a small study it illustrates the need for caution when interpreting and acting on the results of proctography.

There is limited work on the relationship between clinical symptoms and radiological findings in patients with pelvic floor disorders. The methods used to identify both pelvic floor disorders and symptoms vary greatly. Harewood (1999) found an association between PD and the symptom of straining in a small group of patients who had completed a course of biofeedback training.[70] Dietz (2005) examined a large series of urogynaecological patients (505 women) using translabial ultrasound scanning; 54% were found to have a 'true rectocele' (a demonstrable defect in the rectovaginal septum). This finding was strongly associated with the symptoms of incomplete bowel emptying and vaginal digitation and to a lesser extent with difficult defaecation, chronic constipation and faecal incontinence.[95] Recently Broekhius et al (2010) used magnetic resonance imaging in combination with the Urogenital Distress Inventory and Defaecatory Distress Inventory questionnaires to explore the relationship between perineal position and descent and clinical symptoms. The only symptom associated with PD in this study of 69 women was that of genital prolapse.[71] In the evaluation of a new technique for rectocele repair D'Hoore (2008) developed a scoring system to assess the symptoms of rectocele. This includes many of the symptoms traditionally associated with the condition such as; prolapse, straining, manual support and digitation,

incomplete or obstructed defaecation and tenesmus.[180] Altomare et al (2007) have created and validated a simple 8-point questionnaire for the assessment of obstructed defaecation syndrome.[181] This type of doctor-administrated assessment tool may be of more value in recording symptoms pre- and post-operatively than extensive patient reported questionnaires.

Rectocele, RI, enterocele and PD may all be present in patients with obstructed defaecation. Pescatori (2006) described obstructed defaecation as an "iceberg syndrome".[128] Surgical correction of the obvious or prominent condition may fail because of occult lesions which are not taken in to consideration. As well as connective tissue injuries this may include a degree of pelvic floor dysynergia and psychological factors like anxiety and depression.

The current work could be expanded in the future to include other parameters of pelvic floor physiology including anal manometry, endoanal ultrasound and pudendal nerve function. As the pathophysiology of pelvic floor dysfunction is multifactorial the current study does not take into account the contribution of anal sphincter muscle weakness and pudendal neuropathy to clinical symptomatology. Manometry values would be particularly useful in determining the influence of RI and rectocele in patients with faecal incontinence. Although there is a statistical association between certain proctogram findings and clinical symptoms the presence of a particular anatomical defect on proctography cannot be considered a reliable or specific indicator of pelvic

floor pathology therefore it would be unsafe to proceed to correction of this defect on this basis alone.

Summary

RI was associated with the most clinical symptoms in this study. PD was not significantly associated with any of the common symptoms of pelvic organ prolapse, anorectal dysfunction or urinary dysfunction. Larger rectoceles were associated with the sensation of a vaginal bulge but not with vaginal digitation. The sensation of rectal prolapse was a common complaint which was often present despite an absence of external prolapse demonstrated on proctography.

There are many available questionnaires to document pelvic floor symptoms and the impact such symptoms have on quality of life. Defaecating proctography remains a valuable way of assessing patients with pelvic floor disorders but other techniques such as transperineal and endoanal ultrasound and dynamic magnetic resonance imaging are now also being employed to assess these patients. The aim of this study was to determine whether certain symptoms were reliably associated with specific proctographic findings. Using symptoms to predict the presence of pelvic floor disorders can be an aid to diagnosis but pelvic floor dysfunction is a complex condition which reflects a global insult to the muscles, nerves and connective tissues of the pelvic floor. Patient-reported questionnaires are a useful way to provide a symptom inventory but they are probably more valuable in establishing the impact of symptoms on quality of life. Simple clinical tools such as that of Altomare et al [181] may be of use in

clinical trials or to determine outcomes after surgery. The decision to operate should continue to be made on an individual basis taking into account a variety of factors which should include but not solely rely on radiological imaging.

Chapter 6. Connective tissues changes in rectal prolapse

6.1 Aim

The aim of this study was to determine whether the quantity and organisation of collagen and elastin in connective tissues is different in females with rectal prolapse compared to females without rectal prolapse. Biopsies were taken from the abdominal wall, pelvic floor fascia and thigh of patients undergoing surgical repair of a rectal prolapse and compared to biopsies taken from patients without pelvic floor symptoms undergoing abdominal or pelvic surgery for an unrelated pathology.

6.2 Patients

Ethical approval was obtained from the Greater Manchester East Research Ethics Committee and written consent was taken from all participants (REC Reference Number 11/H1013/2). Potential participants were identified using University Hospital of South Manchester surgical waiting lists.

6.2.1 Inclusion criteria

Female patients having elective surgery (abdominal rectopexy) to repair a rectal prolapse at the University Hospital of South Manchester were included in the study. Female patients without pelvic floor disorders who were having abdominal or pelvic surgery (including colorectal resections for cancer, inflammatory bowel disease or diverticular disease and gynaecological procedures) were recruited to act as normal controls.

6.2.2 Exclusion criteria

Patients were excluded if they had dementia or other cognitive problems affecting their ability to give informed consent. The number of male patients with rectal prolapse that presented during the study period was insufficient to provide an adequate sub group for analysis therefore male patients were excluded from this study.

6.3 Methods and materials

Abdominal rectopexy is performed by two Consultant Surgeons at the University Hospital of South Manchester. Approximately 30 patients undergo the procedure at this site each year. The operation is carried out under general anaesthesia and in this study an open technique was used in all cases. Consent was obtained from participants on the morning of surgery or one week prior to this in the pre-operative assessment clinic. Demographic details including age, parity and menopausal status were recorded for each participant. The control group participants were questioned to ensure that they did not have any symptoms of pelvic organ prolapse, difficult defaecation, faecal or urinary incontinence.

6.3.1 Joint mobility assessment

Joint mobility was assessed using the Beighton Score at the time of gaining consent (chapter 3).

6.3.2 Biopsy technique

Biopsies were taken in the operating theatre after the administration of general anaesthesia. Tissue samples were taken from the following three anatomical sites; the rectus sheath, the pelvic floor fascia (tissue from the Pouch of Douglas or the rectovaginal septum) and the subcutaneous tissue of the anterior thigh. Free hand biopsies of the rectus sheath and the pelvic floor fascia were taken during the operation. A Pfannenstiel lower abdominal transverse incision or a lower midline laparotomy incision were used for access. The rectus sheath biopsies were taken during the incision of the abdominal wall. The pelvic floor tissue was biopsied following postero-lateral mobilisation of the rectum, prior to suture fixation of the rectum to the sacrum. This tissue was taken from the Pouch of Douglas or the rectovaginal septum depending on the extent of the distal mobilisation of the rectum.

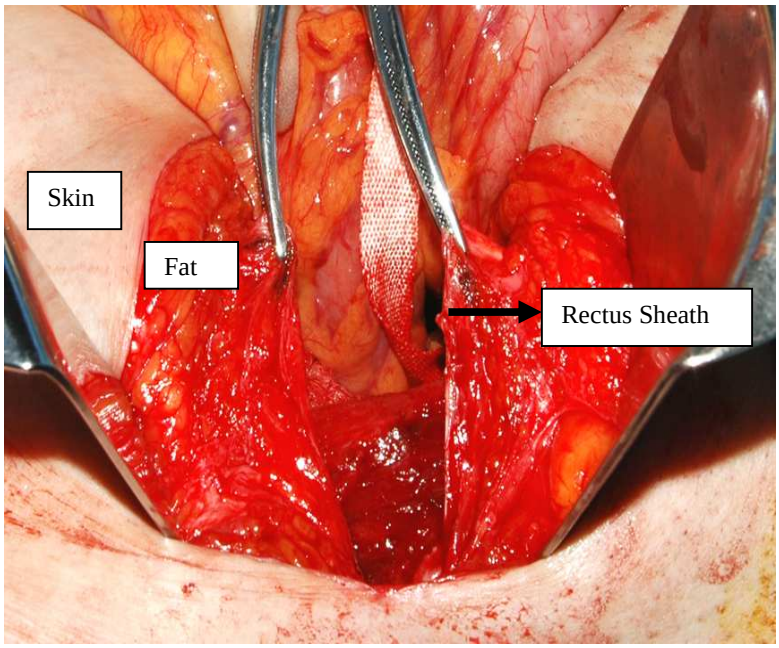


Figure 47. Pfannenstiel skin incision for abdominal rectopexy showing the layers of the abdominal wall

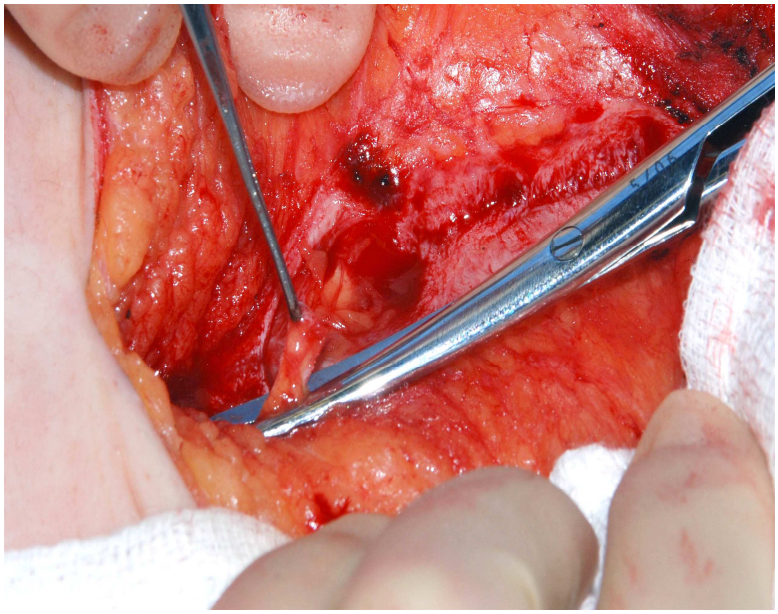


Figure 48. Rectus sheath biopsy

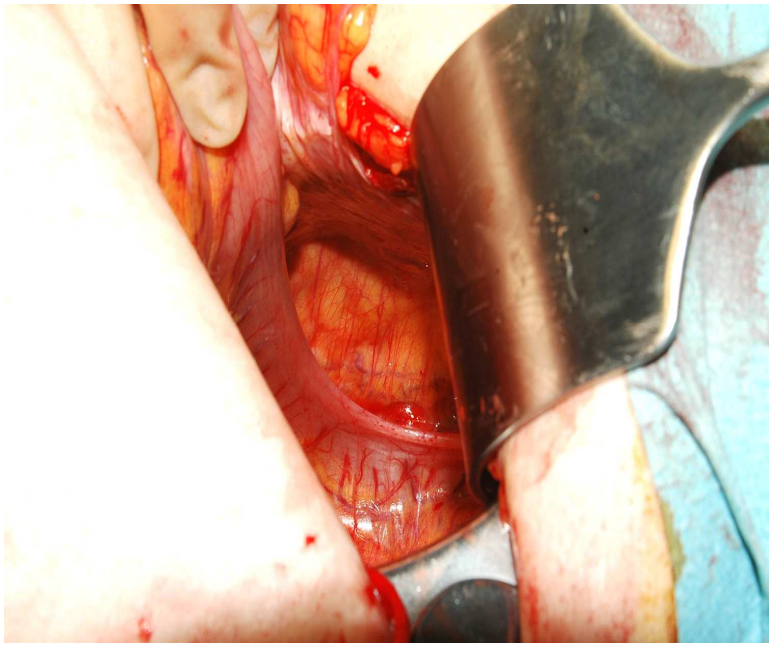


Figure 49. View of the anterior rectum in the pelvis

A disposable 16 gauge core biopsy needle (inter.v SuperCore Biopsy Instrument™) was used to take a single biopsy of the subcutaneous tissue of the anterior thigh. This sample was taken following the operation while the patient remained under anaesthesia. The skin of the anterior thigh was prepared with antiseptic solution prior to taking the biopsy and the puncture wound was covered with a sterile dressing afterwards. The subcutaneous tissue overlying the right quadriceps muscle was sampled in each case.

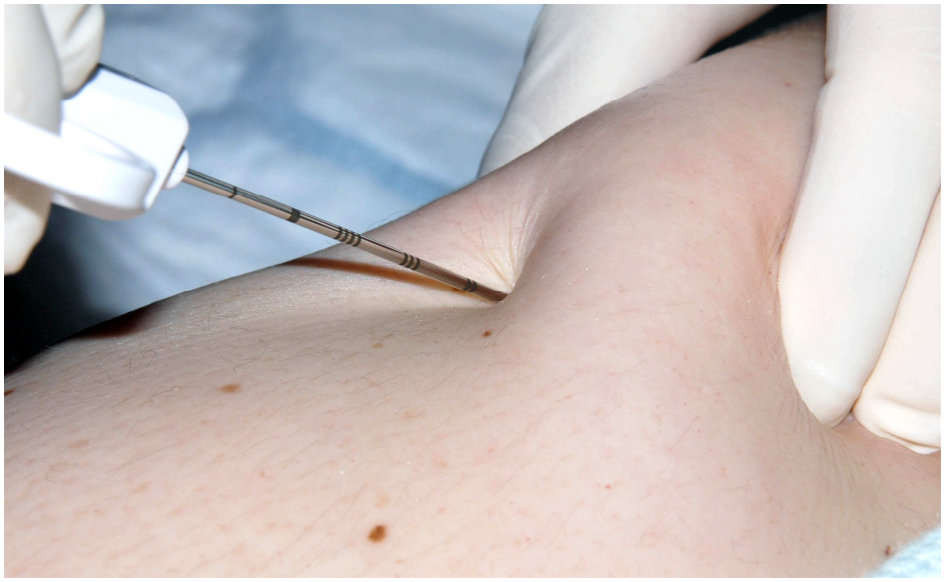


Figure 50. Needle core biopsy of subcutaneous tissue of thigh

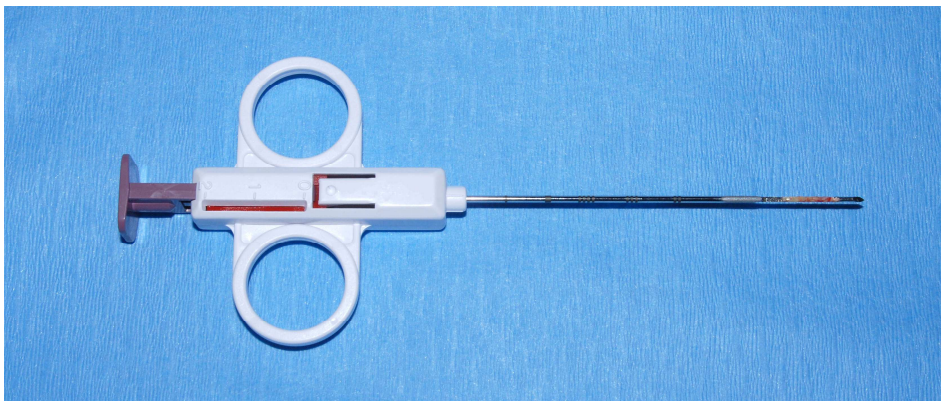


Figure 51. Biopsy needle containing subcutaneous tissue from the thigh

The biopsies from each site were fixed in 10% neutral buffered formalin. The specimen pots were labeled with the patient trial number and the specimen details before being transported to the Histopathology laboratory at Manchester Royal Infirmary.

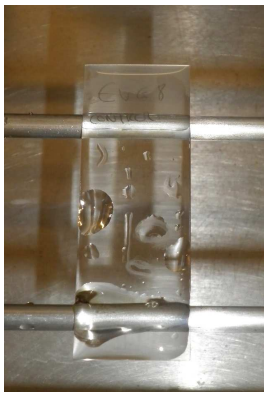
6.3.3 Tissue processing, embedding and cutting of sections

Each specimen was placed in a cassette labeled with the corresponding trial number. An automated tissue processor using a routine overnight programme was used to process and embed the tissue in paraffin wax. The paraffin wax blocks were trimmed to maximally expose the surface area of the tissue. A Leica RM2245 rotatory microtome was used to cut a ribbon of sections at a thickness of four micrometres. Individual sections were placed in a water bath (42^{o}c) to flatten out any creases in the wax. Sections were then orientated, positioned on a glass slide and allowed to dry. The tissue processing and staining was performed by laboratory technicians observed and assisted by myself.

6.3.4 Staining techniques

Conventional tinctoral stains were used throughout. An automated staining instrument was used to perform haematoxylin and eosin staining for morphology. The Elastic Van Gieson technique was used to demonstrate the collagen and elastin content of the specimens. The slides were stained in batches using a control slide of a section of unrelated artery for each batch. The sections were rehydrated using three stages each of xylene and industrial methylated spirit. The sections were washed in water and then stained with 0.5% potassium permanganate solution for five minutes. The sections were

rinsed with water then decolourised using 2% oxalic acid. They were then rinsed in water and alcohol before being stained with Miller's elastin for up to three hours.


Figures 52, 53, 54 . Slides stained with 0.5% potassium permanganate, washed with 2% oxalic acid and stained with Miller's elastin stain

Following this stage the control slide was examined under the microscope to ensure that the elastic fibres had been adequately stained dark blue. The sections were rinsed in alcohol and placed in Van Gieson solution for two minutes. The sections were then dehydrated by being taken back through the initial stages of xylene and industrial methylated spirit. Cover slips were then applied using a xylene- based mountant (Pertex).

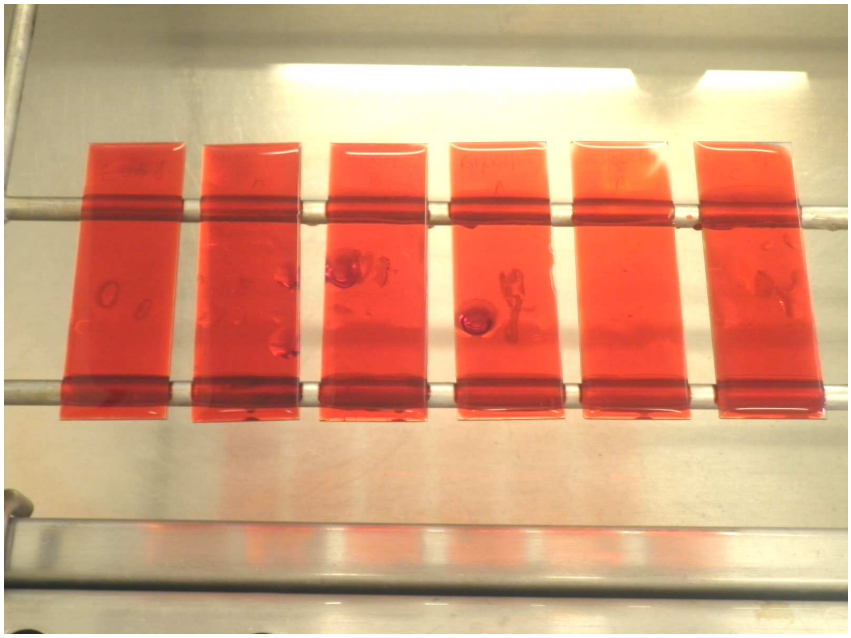


Figure 55. Slides stained with Elastic Van Gieson stain

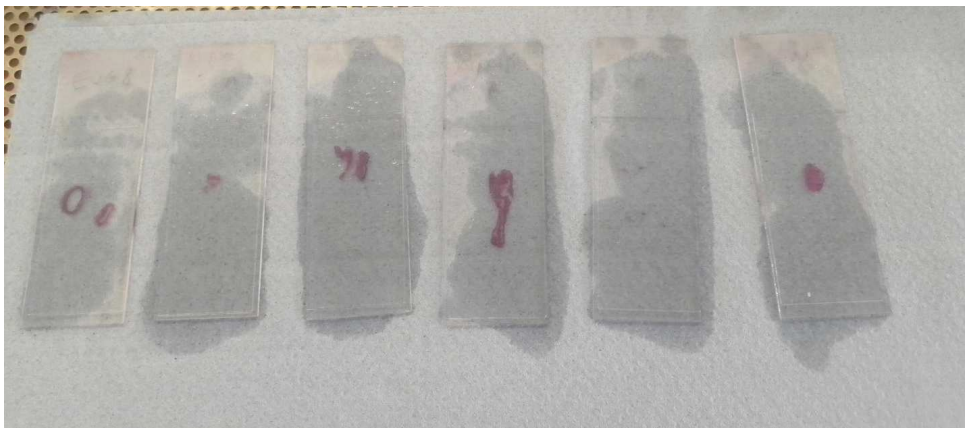


Figure 56. Slides following completion of Elastic Van Gieson staining

6.3.5 Slide examination

A standard method was used to provide a semi-quantitative estimate of collagen and elastin content and organisation. This involved examination of the slides by a single Professor of Osteoarticular Pathology on one occasion, the examiner was blinded to the clinical history of the patient. Simple grading systems were devised to assign arbitrary

scores to each slide based on an estimate of the percentage of collagen and elastin present and the organisation of collagen and elastin fibres. The fibres in well organised collagen form densely packed longitudinal bundles. In poorly organised collagen the fibres appear as loosely aggregated clumps. A score of 0 to 3 was assigned according to the perceived degree of organisation.

Figure 57. Grading system for collagen content

	Percentage of collagen in specimen			
	Nil seen	<25%	25-75%	>75%
Score	0	1	2	3

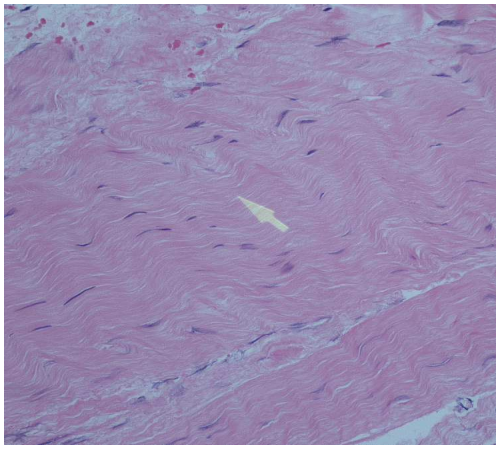


Figure 58. Rectus sheath H+E x20 magnification
Collagen content >75% (score 3)
Collagen organisation good (score 3)
Arrow: densely packed collagen bundles

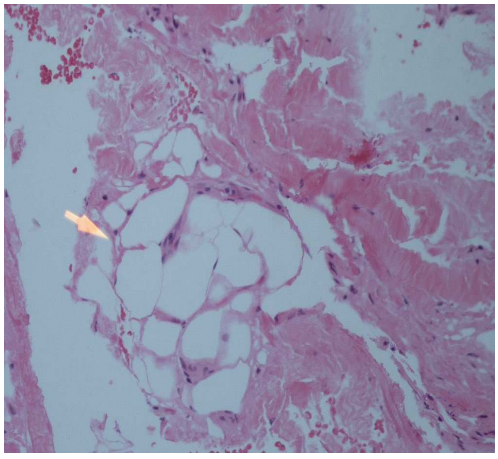


Figure 59. Rectus sheath H+E x20 magnification
Collagen content >75% (score 3)
Collagen organisation poor (score 1)
Arrow: fat cells interspersed in loosely packed collagen

Figure 60. Grading system for collagen organisation

	Collagen organisation in specimen			
	No collagen seen	Poorly organised	Intermediate organisation	Good organisation
Score	0	1	2	3

With the Elastic Van Gieson method collagen stains pink-red, elastin stains dark blue and muscle appears yellow. The actual percentage of elastin present was estimated rather than using a scoring system. This was because the amount of elastin in these tissues was expected to frequently be between 0 and 50% therefore this system made it possible to distinguish between cases which may have otherwise been grouped together if a range had been used.

Well organised elastin forms rope-like bundles of fibres whereas poorly organised elastin is seen as a mesh of loosely aggregated knots. A score between 0 and 3 was assigned based on the perceived degree of organisation.

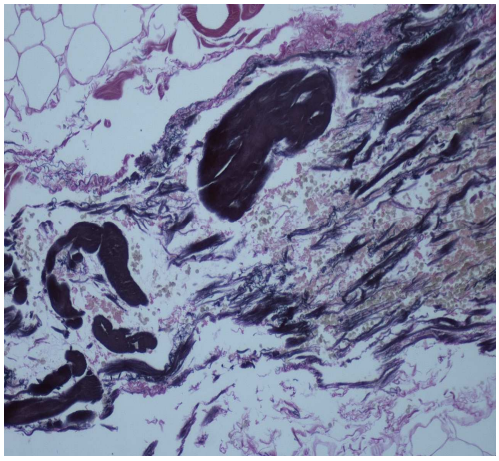


Figure 61. Pelvic floor fascia EVG x20 magnification
Elastin content 70%
Elastin organisation good (score 3)

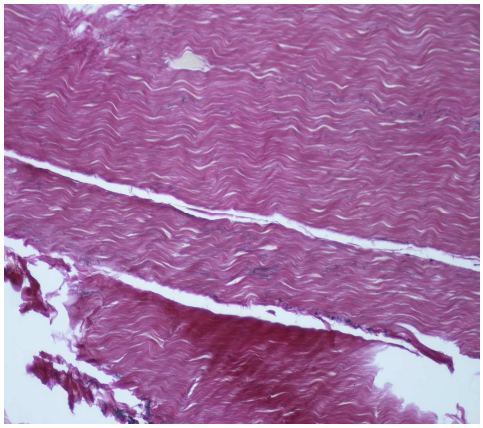


Figure 62. Rectus sheath EVG x20 magnification
Elastin content 5%
Elastin organisation intermediate (score 2)

Figure 63. Grading system for elastin organisation

	Elastin organisation in specimen			
	Nil seen	Poor organisation - knots	Intermediate organisation - some knots	Good organisation-fibrillar
Score	0	1	2	3

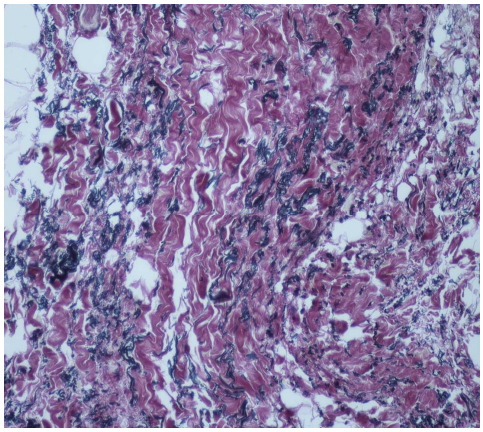


Figure 64. Pelvic floor fascia EVG x40 magnification
Elastin content 30%
Elastin organisation poor (score 1)

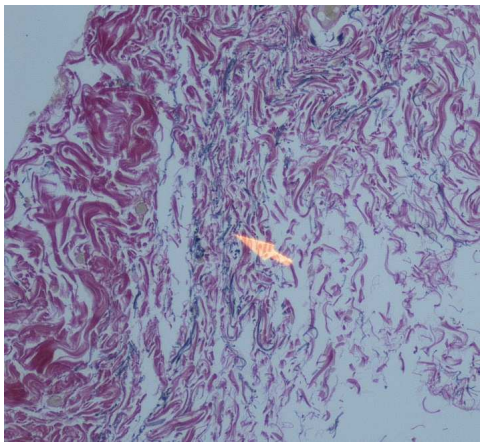


Figure 65. Pelvic floor fascia EVG x20 magnification
Elastin content 40%
Elastin organisation good (score 3)
Arrow: fibrillar elastin

6.3.6 Data analysis

Data analysis was performed using SPSS® for Windows version 16.0 (SPSS Inc, Chicago, IL). The rectal prolapse and normal groups were compared using linear regression modeling with generalised estimating equations which adjusted for multiple biopsies.

6.4 Results

Biopsies were obtained from a total of 27 female patients. Abdominal rectopexy was performed in 18 patients with rectal prolapse, one patient who underwent a posterior colporrhapy to repair a rectocele was included in the prolapse group and the remaining 8 patients were normal controls. The rectal prolapse group were significantly older than the control group (64 years versus 47 years, compared using independent samples t test, p=0.01). The median Beighton score was 0 in both groups but the control group had a higher maximum score with a range of 0 to 4. The range of the Beighton score in the prolapse group was 0 to 2. The median parity in the rectal prolapse group was 2 with a range of 1 to 5 (data was unavailable in 3 cases). In the control group the median parity was 0 with a range of 0 to 3, five of the control patients were nulliparous.

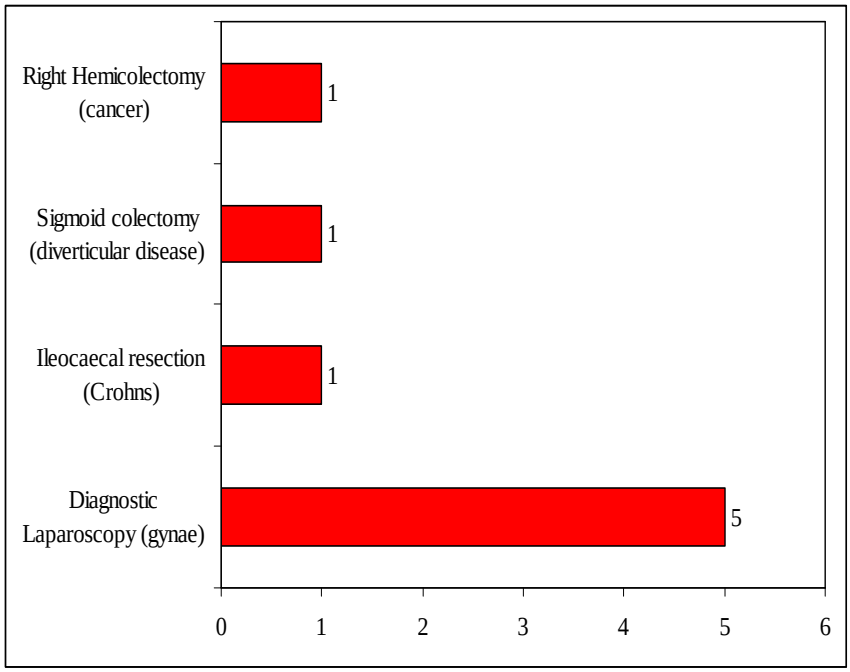


Figure 66. The operations performed in control patients

During the examination of the slides it was noted that some biopsies included two very distinct areas. This was only observed in the rectal prolapse group and it was seen in biopsies taken from both the rectus sheath and the pelvic floor fascia. In these cases the two areas were scored separately and thus classed as two different biopsies from the same site in the same individual. This was the case for five of the rectus sheath biopsies and two of the pelvic floor fascia biopsies.

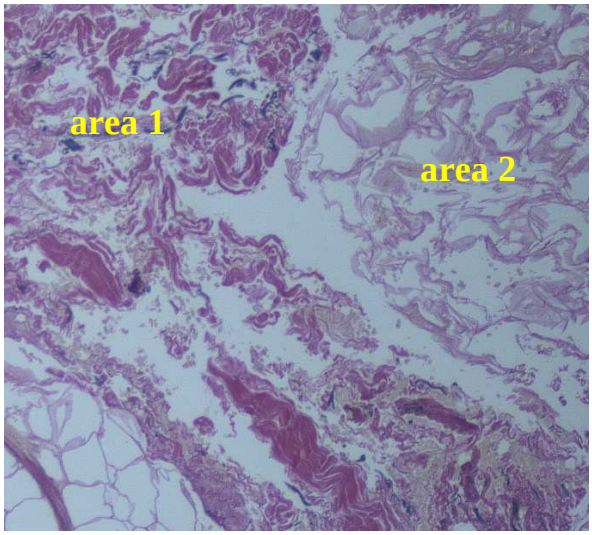


Figure 67. Rectus sheath H+E x10 magnification showing two distinct areas
area 1: >75% well organised collagen
area 2:>75% poorly organised collagen

In the rectal prolapse group two patients did not have a biopsy taken from the rectus sheath. In one case this was because a posterior colporrhapy was performed and therefore the abdomen was not opened and in one case there was difficulty obtaining an adequate tissue sample because of multiple previous operations. In the control group all eight participants had one biopsy of the rectus sheath.

In the rectal prolapse group two patients did not have a biopsy taken from the pelvic floor fascia because of technical difficulties during the procedure. In the control group five patients had a single biopsy of the pelvic floor fascia. In one case two biopsies were taken as there was concern about the adequacy of the sample. Both biopsies were adequate and were therefore both processed. In the cases of the remaining two control patients a single biopsy was taken from the pelvic floor fascia but they could not be included in the analysis because one contained a significant degree of endometriosis which affected the interpretation of the slides and one contained only fat.

Ten participants consented to have a biopsy taken from the subcutaneous tissue of the thigh (eight patients with rectal prolapse and two control patients). Five of these samples contained fat and two contained muscle only and were therefore not included in the study. Two of the viable samples were from rectal prolapse patients and one was from a control patient. In all three cases the collagen content was between 25 and 75% but it was poorly organised. The elastin content was estimated at 30 and 80% in the prolapse patients and 50% in the control and in all cases the elastin was well organised. No statistical analysis was possible due to the very small number of biopsies.

As some biopsies contained two areas with a distinctly different connective tissue composition the variability between biopsies taken from the same site in the same individual was great therefore averages were not used in the statistical analysis. Instead each separate biopsy result was included and nested within each subject and the rectal prolapse and normal groups were compared using linear regression modeling with generalised estimating equations which adjusted for multiple biopsies.

An exploratory analysis was performed by dichotomising the scores for collagen content, collagen organisation and elastin organisation. Scores of 0 and 1 were grouped together and scores of 2 and 3 were grouped together. In the case of elastin content the mean percentage was used in each group.

It was not possible to analyse the rectus sheath collagen content as only one biopsy from this site had a collagen content of less than 25% therefore the statistical model was not valid.

The collagen content of the pelvic floor fascia biopsies did not vary statistically between the two groups.

Table 46. Collagen content of pelvic floor fascia biopsies

Biopsy site	Collagen content ≥ 25% (scores 2+3)		Comparison
	Rectal Prolapse group (n = 19)	Control group (n = 7)	
Pelvic floor fascia	65%	83%	P= 0.41

Data are percentage of biopsies with ≥ 25% collagen in each group
n=number of biopsies

There was no statistically significant difference between the groups in terms of the percentage of biopsies with intermediately organised or well organised collagen. There was also no significant difference between the rectal prolapse group and the controls in terms of the organisation of the collagen in the rectus sheath biopsies.

Table 47. Collagen organisation of rectus sheath biopsies

Biopsy site	Intermediate or good collagen organisation (scores 2+3)		Comparison
	Rectal prolapse group (n=22)	Control group (n=8)	
Rectus sheath	70%	75%	P=0.77

Data are percentage of biopsies with good or intermediate collagen organisation in each group
n=number of biopsies

Table 48. Collagen organisation of pelvic floor fascia biopsies

Biopsy site	Good or intermediate collagen organisation (scores 2+3)		Comparison
	Rectal prolapse group (n=19)	Control group (n=7)	
Pelvic floor fascia	34%	50%	P=0.25

Data are percentage of biopsies with good or intermediate collagen organisation in each group
n=number of biopsies

Tables 49 and 50 show the mean percentage of elastin in each biopsy site, there was no significant difference in elastin content between rectal prolapse patients and controls.

Table 49. Elastin content of rectus sheath biopsies

Biopsy site	Mean (95% confidence interval)		Comparison
	Rectal prolapse group (n=22)	Control group (n=8)	
Rectus sheath	29.6 % (22.8, 36.4)	21.9 % (9.0, 34.7)	P= 0.30

Data are means + 95% confidence intervals of percentage of elastin in each group
n=number of biopsies

Table 50. Elastin content of pelvic floor fascia biopsies

Biopsy site	Mean (95% confidence interval)		Comparison
	Rectal prolapse group (n=19)	Control group (n=7)	
Pelvic floor fascia	24.9% (16.8, 33.0)	14.2% (4.6, 23.9)	P= 0.10

Data are means + 95% confidence intervals of percentage of elastin in each group
n=number of biopsies

The organisation of the elastin in the pelvic floor fascia was the only parameter to show some evidence of a possible difference between the rectal prolapse group and the controls (p=0.06; borderline statistical significance). In the rectal prolapse group 89% of the biopsies showed intermediate to good elastin organisation but in the control group

less than half of the biopsies (48%) showed this degree of organisation. This was the only comparison in the study to near statistical significance (p=0.06).

Table 51. Elastin organisation in pelvic floor fascia biopsies

Biopsy site	Intermediate or good elastin organisation (scores 2+3)		Comparison
	Rectal prolapse group (n=19)	Control group (n=7)	
Pelvic floor fascia	89%	48%	P=0.06

Data are percentage of pelvic floor fascia biopsies with good or intermediate elastin organisation in each group
n=number of biopsies

Table 52. Elastin organisation in rectus sheath biopsies

Biopsy site	Intermediate or good elastin organisation (scores 2+3)		Comparison
	Rectal prolapse group (n=22)	Control group (n=8)	
Rectus sheath	89%	88%	P=0.90

Data are percentage of rectus sheath biopsies with good or intermediate elastin organisation in each group
n=number of biopsies

Tissue taken from six patients with rectal prolapse was found to have two distinct areas which, because of the marked difference in their composition were treated as separate biopsies. Table 53. shows the scores assigned to each of the two areas in each subject. The collagen content was greater than 25% in all cases. In four cases the collagen was well organised in one of the areas but poorly organised in the other. In six cases the elastin content was different in each of the two areas. Those areas of tissue with a higher percentage of elastin generally showed better organisation than those with a lower percentage of elastin present.

Table 53. Patient details and histology grading scores for biopsies with two distinct areas

Age	Parity	Beighton score	Biopsy site	Collagen content		Collagen organisation		Elastin content %		Elastin organisation	
				1	2	1	2	1	2	1	2
46	4	1	Rectus sheath	3	3	2	3	50	10	3	2
74	3	2	Pelvic floor	2	3	0	1	50	25	3	3
78	2	0	Rectus sheath	2	2	1	3	30	10	3	2
37	1	0	Rectus sheath	3	3	3	1	10	60	2	3
49*	3	2	Rectus sheath	3	2	3	1	10	50	2	1
49*	3	2	Pelvic floor	3	2	2	1	5	5	2	3
78	3	0	Rectus sheath	3	2	3	2	5	20	2	1

**** the same patient***

6.5 Discussion

In this small study of 18 females with rectal prolapse (one female with rectocele) and 8 normal controls the total amount of collagen in both the rectus sheath and the pelvic floor fascia did not vary statistically between the study group and the controls.

No previous studies have assessed the connective tissue composition of the supporting structures of the pelvic floor in patients with rectal prolapse. Several groups have, however, attempted to evaluate the changes in collagen, elastin and other extracellular matrix proteins in the vaginal tissue, parametrial and periurethral ligaments of women with urogenital prolapse and urinary incontinence.[33, 35, 38, 40-42, 165, 166, 168-171] The analytical methods utilised in these studies varied considerably and included histology using image analysis or semi-quantitative techniques, immunohistochemistry and hydroxyproline assay techniques. Participant numbers were generally small. In 2009 Kerkhof et al [29] reviewed the literature in this area. Five studies included biopsies from the vaginal tissue of women with urogenital prolapse and compared these to controls. Two of these studies found no difference in collagen content,[35, 165] two found a decreased amount of collagen in those women with prolapse [38, 170] and one study found an increased amount of total collagen in the prolapse group.[33] Biopsies from the parametrial ligaments including the uterosacral and cardinal ligaments were analysed in nine studies. Kokcu et al (2002) found an increase in total collagen in these structures, this study used a similar grading system to the one utilised in the current work to evaluate collagen and elastin content. (See page chapter 1). [33] Two further studies found an increase in type III collagen only.[40, 42] The remaining six studies

[35, 41, 168, 169, 171] found a decrease in total or type III collagen in women with prolapse although in the work of Liapis et al this was only significant in women with pelvic organ prolapse plus symptoms of urinary incontinence.[166] One reason for the discrepancy in the outcomes of these studies is that not all of them included analysis of the collagen type ratio. Changes may occur in the collagen type ratio without affecting overall collagen content. An increase in type III collagen compared to type I is seen in tissues that are granulating or healing and may reflect a response to injury.

We know that individuals with heritable connective tissue diseases are at increased risk of developing pelvic organ prolapse.[164] Collagen abnormalities are common in patients with classic Ehlers-Danlos syndrome [146] but it is the mutation of the fibrillin-1 gene (which encodes the protein fibrillin, found in elastin fibres) that is responsible for Marfan's syndrome.[45] In the current study the mean percentage of elastin in both the rectus sheath and pelvic floor tissue was greater in the rectal prolapse group than the controls although this was not statistically significant. In the literature the consensus is that the total elastin content is decreased in the vaginal tissue and uterosacral ligaments of women with urogenital prolapse [42, 182] [171, 183-185], although two studies [38, 186] found no difference and the methods used to measure elastin varied greatly.

As the above studies demonstrate a reduced quantity of collagen and elastin may play a role in the pathophysiology of pelvic organ prolapse but changes in collagen metabolism and organisation may also be of relevance. The current study did not analyse changes in collagen type ratio or collagen degradation and was therefore unable to comment on

collagen turnover. The organisation of collagen in the rectus sheath biopsies appeared to be similar in both groups with a high percentage (70 and 75% in the prolapse and control groups respectively) showing intermediate to good organisation. Half of the pelvic floor fascia biopsies from the control group showed intermediate to good collagen organisation compared to only 34% of the prolapse group biopsies, this was not a statistically significant difference. Barbiero et al (2003) commented on the organisation of collagen fibres in the parametrium of women with uterine prolapse. The fibres were shorter and more loosely aggregated than those seen in women without prolapse.[187] With the very small numbers in the current study we are unable to conclude that disordered collagen organisation either contributes to the cause of prolapse or is an effect of injury sustained during pregnancy and childbirth.

Organisation of elastin in the pelvic floor fascia biopsies was the only parameter to near a statistically significant difference between the study and control group in the current work; 89% of the study group biopsies showed intermediate to good organisation compared to 48% of the control biopsies. This suggests better elastin organisation in the pelvic floor tissue of the rectal prolapse patients. Interestingly this study found that some biopsies from both the rectus sheath and the pelvic floor in patients with rectal prolapse showed two distinct areas with a different composition of connective tissue. Generally one of the two areas showed a greater amount of elastin and this showed better organisation than that in the area where the percentage of elastin was less. This is not in keeping with the studies in the literature which show a reduced amount of elastin in the pelvic floor tissues of patients with pelvic organ prolapse. Elastic fibres appear

late in the wound healing process,[188] the organisation of these fibres may then be affected by the dynamics of the particular anatomical site with different patterns of organisation reflecting the movement of the underlying tissue. The above pattern observed in the two areas within biopsies may be related to the older age or greater parity of the prolapse patients or it may be a reflection of an injury which has healed with a well organised structure of elastin.

The aetiology of rectal prolapse is multifactorial. This study was designed to try to determine whether an underlying variation in the composition of the connective tissues could contribute to the development of this condition; because the pelvic floor is subjected to trauma during pregnancy and childbirth biopsies were taken from the pelvic connective tissues. The rectus sheath is also stretched during pregnancy but this trauma is less than that sustained by the pelvic floor during a vaginal delivery; this area is also easy to access during abdominal and pelvic surgery and thus was chosen to act as an intra-subject control. In order to find out whether patients with rectal prolapse had a generalised connective tissue abnormality biopsies were also taken from the thigh, a site which was less likely to have been altered by an injury related to pregnancy. The aim was to sample the fascia lata which is thicker in the upper and lateral part of the thigh and is avascular but collagen dense and also contains variable amounts of elastin. As would be expected from anatomical sites which require tensile strength the quantity of collagen was high in all the biopsies from the rectus sheath and to a lesser extent, the pelvic floor. As a biopsy from the thigh has the potential to scar participants were asked to consent to this part of the study separately. Seventeen subjects refused to have a

biopsy taken from this site. A needle core biopsy provides a very small sample of tissue only and seven of the biopsies were unsuitable for analysis. This unfortunately meant that this area of the study could not be included. An open biopsy would provide a larger tissue sample but is less likely to be acceptable to the patients. Three of the core needle samples were however adequate. There is undoubtedly a learning curve associated with this type of technique, it is likely that the adequacy of samples would improve with increased experience and therefore this part of the study could be completed in the future.

The main limitation of this study was the sample size. With only eight subjects in the control group the statistical analysis is not robust enough to draw any definite conclusions. This reflects the difficulty in recruiting patients for studies which require tissue biopsies. In the above mentioned collagen analysis studies of urogenital prolapse the recruitment numbers were also low ranging from 5 to 46 for patients with prolapse and 5 to 28 for controls.[33, 35, 38, 40-42, 165, 166, 168-171] Recruitment was limited in this study by the number of patients undergoing surgery for rectal prolapse in our institution during the study period. The recruitment of control patients was also difficult as participants were required not to have any symptoms of pelvic floor dysfunction (including minor degrees of urinary incontinence) and not to have a condition which may affect the tissue analysis (e.g. endometriosis or Crohns disease). An ideal "control" operation would give good access to the pelvis for example an anterior resection for rectal cancer. As patients undergoing this type of ideal procedure were older in age they often had pelvic floor symptoms and were therefore excluded. Five of the eight control

patients recruited for this study had minor gynaecology procedures. Difficulty recruiting control patients meant there was a bias in the control group towards younger, nulliparous women. The median Beighton score in both groups was 0, but one 28 year old control patient did have a significant score of 4. As previously discussed in chapter 3 the Beighton score may not be an adequate tool to detect joint hypermobility in the older and often post menopausal patients in the rectal prolapse study group.

This small pilot study employed the semi-quantitative method of using a pathologist to grade specimens using appropriate scoring systems. This is a standard method employed in histopathological studies, it was chosen because some of the above mentioned studies of connective tissue changes in urogenital tissues also used this method of estimated quantification of collagen following histological staining [33, 165] and immunohistochemical staining [41]. In particular Kokcu et al (2002) used a similar grading system to the one utilised in the current work to evaluate collagen and elastin content.(See page chapter 1).[33] The Elastic Van Gieson stain is commonly used in clinical practice and routinely used at the Histopathology laboratory where this study was carried out. It incorporates the Verhoeff's elastic stain and dyes collagen fibres pink, elastic fibres black and muscle tissue yellow. Elastic Van Gieson was used in preference to the Masson's trichrome technique as the latter does not stain elastic fibres and therefore only allows comparison of muscle and collagen.

The slides were examined by one pathologist on one occasion only. If this study were to be expanded the accuracy of the observations could be improved by viewing the slides

on a second occasion or by using an additional second examiner. The use of image analysis and immunohistochemistry would give a more quantitative assessment of collagen and elastin content. It would be interesting to continue to look at the fibre organisation but in view of the published literature in this area within urogynaecology expanding the study to evaluate the ratio of collagen types I and III and the activity of the proteases involved with the breakdown of collagen and elastin may provide more information. As the pelvic floor connective tissues are affected by other factors including age, hormonal status and parity it would be necessary to recruit a greater range of subjects including younger patients with rectal prolapse and male patients with and without prolapse.

To detect statistically with 80% power differences in collagen content and organisation of the magnitude observed in this study the number of biopsy samples would need to be approximately 100 per group.

Summary

Within the limits of this small pilot study there was no difference in either the collagen or elastin content of rectus sheath or pelvic floor tissue between the two groups. The pelvic floor tissue of patients with rectal prolapse tended to show greater degrees of elastin organisation than that of the control patients, but this difference was not statistically significant. It would be reasonable to expand this study by recruiting more participants. In order to quantify the collagen and elastin content more accurately image analysis software or immunohistochemistry could be used. It is difficult to interpret the

relevance of the organisation of collagen and elastin fibres with regards to the current literature, it may be more useful to analyse collagen type ratios and matrix metalloproteinase activity in order to evaluate collagen metabolism or to determine the number of fibroblasts in the tissues as it is these cells that give rise to collagen and elastin.

This study was unable to comment on the presence of a generalised connective tissue disorder in patients with rectal prolapse as the biopsies taken from the thigh were unsuitable for analysis. It would be particularly useful to expand this part of the study in combination with the recruitment of men and nulliparous women with rectal prolapse in order to determine whether different anatomical sites in the same individual vary in terms of connective tissue composition. A better understanding of the aetiology of rectal prolapse may guide surgical management especially in cases of recurrent prolapse.

Chapter 7. Discussion

Perineal descent has been recognised as a physical sign associated with pelvic floor dysfunction since 1966. Initially descent of the perineum was thought to play a causative role in the development of pelvic floor disorders, it is now considered to be the result of stretching or weakening of the connective tissues of the pelvic floor. Previous work on the pathophysiology of faecal incontinence and other pelvic floor disorders has focused on the injury to the anal sphincter mechanism and pudendal nerves. Less is known about the contribution of connective tissue abnormality or injury to the development of these conditions.

PD can be measured using the simple mechanical device, the St Mark's perineometer (developed by Henry in 1982) or during defaecating proctography. Other pelvic floor disorders including RI, rectocele, enterocele and rectal prolapse can also be diagnosed using proctography. These are common findings in patients presenting with symptoms of faecal incontinence, obstructed defaecation and pelvic organ prolapse but some of them may also be present in asymptomatic individuals. We know that obstetric trauma plays a major causative role but other factors must be relevant in male patients and nulliparous females with these disorders.

Joint hypermobility is a common and easily demonstrable sign of connective tissue abnormality. There is an increased incidence of pelvic organ prolapse and faecal and urinary incontinence in people with the serious heritable connective tissue diseases and with the less well recognised and probably under diagnosed, Benign Joint Hypermobility

Syndrome. Urogynaecology studies have demonstrated a difference in collagen content and metabolism in the pelvic floor tissues of women with urogenital prolapse.

The overall aim of this study was to gain a better understanding of the contribution of connective tissue abnormality (both congenital and acquired through trauma) to the development of pelvic floor dysfunction. The study comprises four projects which explore the relevance of PD in a modern setting in the following ways; by testing the accuracy of a new mechanical device for PD measurement, by exploring the relationship between PD and joint hypermobility and by determining the relationship between PD and other pelvic floor disorders and their association with clinical symptoms. Chapter 6 describes a pilot study of the composition of the pelvic floor and abdominal wall connective tissues of patients with rectal prolapse.

There was no correlation found between PD and joint hypermobility. Young nulliparous women were found to have greater PD, this could not be explained by the presence of a generalised connective tissue disorder as their Beighton scores were not higher than those of the older multiparous women. Proctography was used to measure PD as it is the current gold standard method of measurement and the proposed new mechanical device, the laser commode, was not found to be accurate enough for use in this project . The Beighton score was developed over forty years ago in a young African population. It is possible that the nulliparous women in this study do represent a group of individuals with an underlying connective tissue abnormality but the Beighton score was not the appropriate tool to demonstrate this.

PD was associated with chronic constipation (chapter 3) and rectal prolapse but not with rectal intussusception or rectocele formation (chapter 4). This reinforces the theory that chronic straining to defaecate may cause PD. It also suggests that PD either plays a role in the development of rectal prolapse or that descent is worsened by the presence of prolapse. Rectocele was the commonest proctographic finding, there was no association between the presence of rectocele and RI. This study did not show that those patients with the greatest degree of PD also had large rectoceles or high grade intussusception. These findings suggest that PD, rectocele, RI and rectal prolapse share some but not all mechanisms of development and the disorder that predominates is likely to depend on the exact anatomical site of injury or weakness.

There was no association between PD and any of the symptoms of anorectal or urinary dysfunction or pelvic organ prolapse identified using the Pelvic Floor Distress Inventory questionnaire. Rectocele was the commonest pelvic floor disorder identified using proctography but only those greater than 2cm in size were strongly associated with a clinical symptom (the sensation of a bulge into the vagina). RI was the proctographic finding associated with the most clinical symptoms however as proctograms were used alone without additional information from anorectal physiology studies (anal manometry, PNTML and endoanal ultrasound) we cannot assume that other factors such as sphincter weakness and neuropathy did not contribute to these symptoms. Questionnaires are a useful way of documenting symptoms and impact on quality of life pre- and post-operatively, however, this study shows that they cannot be used to predict the presence or severity of certain disorders.

The proctographic methods of measurement used in this study were found to be repeatable and reproducible. The large database of 323 proctogram findings could be expanded and used in future work possibly in combination with anorectal physiology studies or other symptom and quality of life questionnaires to assess the outcomes of surgery or to explore the natural history and progression of RI.

If PD is a useful and relevant sign of connective tissue weakness it would be helpful to have a better non-radiological means of measurement. The laser commode did provide PD measurements closer to that of the gold standard method, proctography than the current mechanical device, the perineometer. However, the inter and intra-rater reliability of the device was not accurate enough with the current design to allow its use in a clinical or research environment.

Interestingly the patients included in this work where found to have less PD than those in previous studies. This may be due to the different proctographic methods and landmarks used or the inconsistency between studies of the point when maximal PD is measured. This may also reflect a change in the patient population as it is possible that those patients included in the historical studies represented a more severely affected and symptomatic group that chose to seek medical help compared to the current climate where there is perhaps more awareness of pelvic floor dysfunction.

The main difficulties encountered during this work were those of obtaining ethical approval and recruiting adequate numbers. Regional Ethics Committee approval was

not granted on two occasions necessitating changes to the study design and delays in starting data collection. This, in addition to the limits imposed by the number of rectopexy procedures performed each year, restricted the number of patients recruited for the connective tissue changes in rectal prolapse study.

This work has revisited the relevance of PD in a modern population of patients with pelvic floor dysfunction. It has shown that PD does not appear to be a marker of severe pelvic floor connective tissue abnormality or injury. This study has demonstrated that the relationship between different pelvic floor disorders (all of which are to some extent affected by connective tissue weakness) is complex.

Future work could explore further the relationship between PD and connective tissue abnormality by measuring PD in patients with known connective tissue diseases. As the Beighton score may not be the best way of delineating connective tissue abnormality in our population other methods could be incorporated including the Brighton criteria, measuring the mobility of a wider selection of joints or by measuring skin stretch. Using age and sex-matched asymptomatic controls would determine whether PD is greater in patients with pelvic floor symptoms compared to the rest of the population.

The proctography measurements could be continued using a prospective approach and this data could be combined with anal manometry or endoanal ultrasonography. This may provide further information about the natural history of RI and the contribution of RI to the symptoms of faecal incontinence and obstructed defaecation.

Connective tissue composition in patients with pelvic organ prolapse is an interesting area which remains unclear. In view of the large volume of patients with prolapse and PD being treated with rectopexy procedures the continuation of this work is likely to have the most clinical relevance. A larger study could be carried out including nulliparous females and males with biopsies from the pelvic floor, thigh and abdominal wall. The use of image analysis to more accurately assess collagen and elastin content and the assessment of collagen type ratios and fibroblast content using immunohistochemistry techniques would be consistent and comparable with the ongoing work in this field.

Summary

1. In this study of 68 patients with pelvic floor dysfunction the laser commode provided PD measurements that were closer to those of the gold standard, proctography than the perineometer but the measurements were not reliable or reproducible enough to use in a clinical setting therefore the new device was not used to measure PD in the other areas of this research project.

2. In this study of 70 females with pelvic floor dysfunction there was no association between PD and joint hypermobility. Patients presenting with chronic constipation had the greatest degree of PD. Young nulliparous women had significant PD without having a generalised connective tissue abnormality demonstrated using the Beighton joint mobility score.

3. In this review of 323 proctograms there was a positive correlation between PD and rectal prolapse but there was no correlation between PD and rectocele formation or RI, and no correlation between rectocele formation and RI.

4. In this study of 133 females who completed the Pelvic Floor Distress Inventory questionnaire there was no association between PD and any of the symptoms. RI was associated with the symptoms of incontinence of formed and liquid stool and flatus and faecal urgency. Rectoceles greater than 2cm in size where associated with the sensation of a bulge into the vagina. The sensation of rectal prolapse was not a sensitive indicator of the presence of rectal prolapse on proctography.

5. In this study of 19 females with rectal prolapse and 8 female controls there was no difference in collagen or elastin content of the rectus sheath or pelvic floor fascia tissues between the two groups. The pelvic floor fascia of the rectal prolapse patients showed a higher percentage of well organised elastin than the control group although this was not a statistically significant difference.

Appendices

Appendix 1 - Intra-rater repeatability of perineal descent measurements using the laser commode

Perineal descent measurements (cm) repeated on three occasions on the same day by the same observer.

Trial no	PD1 rest	PD1 strain	PD1	PD2 rest	PD2 strain	PD2	PD3 rest	PD3 strain	PD3
1	-3	-3.5	0.5	-3.7	-4	0.3	-3	-4	1
2	-1.3	-2.1	0.8	-1	-2.1	1.1	-1.3	-2.1	0.8
3	-1.7	-2.3	0.6	-2	-2.9	0.9			
4	-0.5	0	-0.5	-0.3	-0.7	0.4			
5	-1.1	-1.2	0.1	-1	-2.1	1.1			
6	-2.2	-2.7	0.5	-2.8	-3.3	0.5			
7	-1.5	-1.5	0	-0.7	-1.1	0.4	-0.7	-1.1	0.4
8	-1.7	-2.5	0.8	-2.7	-3.2	0.5	-2.9	-3.5	0.6
9	-3.6	-3.8	0.2	-3.6	-3.9	0.3	-3.6	-4	0.4
10	-1	-1.6	0.6	-0.7	-1.1	0.4	-1.8	-1.5	-0.3
11	-1.8	-2.3	0.5	-2.1	-2.3	0.2	-2.1	-2.3	0.2
12	-1.9	-3.3	1.4	-2.3	-3.4	1.1	-3.2	-3.6	0.4
13	-1.6	-1.6	0	-1.9	-2	0.1	-1.7	-2	0.3
14	-5.7	-6.7	1	-6.1	-7.2	1.1	-6.4	-7.4	1
15	-2.7	-3.4	0.7	-2.7	-3.6	0.9	-3.1	-3.7	0.6
16	-1.6	-2.3	0.7	-2.1	-2.3	0.2	-2	-2.1	0.1
17	-2.9	-3.8	0.9	-3.8	-4.4	0.6	-4.1	-5	0.9
18	-1.9	-2	0.1	-2.6	-3	0.4	-2.2	-2.7	0.5
19	-3.5	-3.4	-0.1	-3.2	-3.9	0.7	-3.5	-4.2	0.7
20	-2.2	-2.6	0.4	-2.4	-2.4	0	-2.2	-2.6	0.4
21	-3.3	-4.4	1.1	-3.5	-4.6	1.1	-3.8	-4.6	0.8
22	-1.9	-2.4	0.5	-2.2	-2.8	0.6	-2.4	-2.7	0.3
23	-1.9	-2.1	0.2	-2.1	-2.2	0.1	-2	-2.2	0.2
24	-2.5	-2.9	0.4						
25	-3.8	-4.9	1.1	-4	-5	1	-4.2	-5.2	1
26	-1.3	-2.2	0.9	-2.2	-2.5	0.3	-2.4	-2.8	0.4
27	-2.7	-2.7	0	-2.2	-2.5	0.3	-2.3	-2.6	0.3
28	-2.1	-2	-0.1	-2	-2.3	0.3	-2	-2.3	0.3
29	-2.5	-2.8	0.3	-1.6	-2.7	1.1	-2.1	-1.2	-0.9
30	-0.1	-0.5	0.4	-0.2	-1.1	0.9	-0.2	-1.1	0.9
31	-1.8	-2.9	1.1	-2.5	-3.1	0.6	-2.7	-3.5	0.8
32	-2	-2.4	0.4	-2.4	-2.4	0	-2.2	-2.5	0.3

33	-2.3	-2.9	0.6	-2.4	-3.3	0.9	-2.3	-3.4	1.1
34	-3.2	-3.2	0	-3.2	-3.3	0.1	-3.2	-3.4	0.2
35	-3.2	-3.3	0.1	-3.1	-3.4	0.3	-3.3	-3.6	0.3
36	-2.2	-2.5	0.3	-2.2	-2.5	0.3	-2.2	-2.8	0.6
37	-1.3	-2	0.7	-1.6	-2.3	0.7	-1.6	-2.3	0.7
38	-3.9	-5.2	1.3						
39	-1.3	-1.9	0.6	-1.5	-1.9	0.4	-1.1	-1.8	0.7
40	-2.2	-2.2	0	-2.1	-2.7	0.6			
41	-1.1	-1.2	0.1	-1.2	-1.3	0.1	-1.2	-1.3	0.1
42	-1.6	-2	0.4	-1.3	-1.7	0.4	-1.4	-1.6	0.2
43	0.3	-0.1	0.4	0	-0.3	0.3	0.1	0	0.1
44	-2.4	-2.6	0.2	-2.5	-2.6	0.1	-2.4	-2.9	0.5
45	-2.7	-3.1	0.4	-2.8	-3.4	0.6	-2.9	-3.5	0.6
46	-5.1	-6	0.9	-5.4	-6.2	0.8	-5.7	-6.3	0.6
47	-3.4	-3.7	0.3	-3.5	-3.9	0.4	-3.5	-3.8	0.3
48	-2.8	-3.3	0.5	-3.3	-3.7	0.4	-3.6	-3.9	0.3
49	-2.3	-2.4	0.1	-2	-2.2	0.2	-2.3	-2.3	0
50	-1.7	-1.6	-0.1	-2	-2.3	0.3	-2.2	-1.6	-0.6
51	-2	-3.2	1.2	-2.5	-2.9	0.4	-2.7	-3.5	0.8
52	-1.9	-1.9	0	-1.7	-2.8	1.1	-1.8	-3.4	1.6
53	-1.4	-1.3	-0.1	-1.4	-2.5	1.1	-2.2	-3.4	1.2
54	-3.1	-3.6	0.5	-3.2	-3.4	0.2	-3.2	-3.4	0.2
55	-1.4	-1.6	0.2	-1.3	-2	0.7	-1.5	-1.9	0.4
56	-0.3	-1.4	1.1	-0.5	-1.3	0.8	-0.6	-1.3	0.7
57	-2.3	-2.8	0.5	-2.3	-2.8	0.5	-2.5	-3	0.5
58	-2.8	-2.8	0	-2.8	-2.8	0	-2.9	-3.1	0.2
59	-0.9	-1.4	0.5	-1.2	-1.7	0.5	-1.1	-1.5	0.4
60	-2.8	-3.1	0.3	-2.6	-2.8	0.2	-2.8	-3	0.2
61	-2.5	-2.5	0	-2.5	-2.7	0.2	-2.7	-2.8	0.1
62	-2	-2.4	0.4	-2	-2.2	0.2	-2	-2.8	0.8
63	-0.2	-0.9	0.7	-0.4	-1.3	0.9	-0.5	-1.2	0.7
64	-3.1	-3.1	0	-3.1	-3.1	0	-3.1	-3.4	0.3
65	-3.4	-4.6	1.2	-3.4	-4.7	1.3			
66	-2.6	-3.5	0.9	-2.8	-3.4	0.6	-2.9	-3.3	0.4
67	-3.7	-4.4	0.7	-3.8	-4.6	0.8	-3.8	-4.9	1.1
68	-5.2	-5.5	0.3	-5.2	-5.2	0	-5.5	-5.6	0.1

Appendix 2 - Intra-rater test-retest reliability of laser commode

Individual raw data PD measurements for four subjects measured on two separate days.

Repeated perineal descent measurements on days 1 (1+2) and 2 (3+4)

Patient	PD Rest 1	PD Rest2	PD Strain 1	PD Strain 2	PD1	PD2
1	-2.5	-1.6	-2.8	-2.7	0.3	1.1
2	-3.4	-3.5	-3.7	-3.8	0.3	0.3
3	-2.3	-2.3	-2.8	-2.8	0.5	0.5
4	-2.8	-2.9	-2.8	-3.1	0	0.2

Patient	PD Rest 3	PD Rest4	PD Strain 3	PD Strain 4	PD3	PD4
1	-0.2	-0.4	-1.4	-1.5	1.2	1.1
2	-2.1	-2.1	-2.5	-2.5	0.4	0.4
3	-3.1	-3.2	-3.6	-3.6	0.5	0.4
4	-2.9	-3.3	-3.8	-3.5	0.9	0.2

Appendix 3 - Inter-rater reproducibility of perineal descent measurements using the laser commode

Perineal descent measurements (cm) taken by two observers (GF and KR) on the same day.

Trial no	GF PD rest	GF PD strain	GF PD	KR PD rest	KR PD strain	KR PD
1	-2.7	-3.6	0.9	-2.3	-3.2	0.9
2	-3.4	-3.7	0.3	-3.7	-4.1	0.4
3	-2.3	-2.9	0.6	-2.9	-3.3	0.4
4	-3	-3.5	0.5	-2.7	-3.2	0.5
5	-3	-3.3	0.3	-3	-3.6	0.6
6	-3.3	-4.7	1.4	-3.5	-4.3	0.8
7	-2.5	-3.2	0.7	-2.7	-3.4	0.7
8	-2.5	-3.2	0.7	-2.8	-2.8	0
9	-3.3	-4	0.7	-2.7	-3.5	0.8
10	-2.8	-3.4	0.6	-2.9	-3.5	0.6
11	-3	-3.3	0.3	-3.1	-3.5	0.4
12	-2.1	-4.2	2.1	-3.2	-4.9	1.7
13	-2.8	-3.4	0.6	-3.1	-3.2	0.1
14	-2.6	-3.6	1	-2.9	-3.9	1
15	-2.9	-3.5	0.6	-2.9	-3.5	0.6
16	-2.6	-3.8	1.2	-2.7	-4	1.3
17	-1.6	-3	1.4	-1.8	-2.1	0.3
18	-0.9	-1.4	0.5	-1.1	-1.4	0.3
19	-1.9	-2.4	0.5	-2.1	-2.7	0.6
20	-1.9	-2.5	0.6	-2.2	-2.6	0.4
21	-4.2	-4.9	0.7	-4.3	-5.1	0.8
22	-2	-2.3	0.3	-2	-2.2	0.2
23	-3.2	-4.2	1	-3.7	-4.3	0.6
24	-1.1	-1.6	0.5	-1	-1.5	0.5
25	-3.5	-4	0.5	-3.8	-4.2	0.4

Appendix 4 - Pelvic Floor Distress Inventory questionnaire

Pelvic Floor Distress Inventory Questionnaire - Short Form 20
Instructions
Please answer all of the questions in the following survey. These questions will ask you if you have certain bowel, bladder or pelvic symptoms and if you do, how much they bother you. Answer each question by putting an **X** in the appropriate box or boxes. If you are unsure about how to answer, please give the best answer you can. While answering these questions, please consider your symptoms over the **last 3 months.**

Research Project ID:

Date:

1. Do you usually experience pressure in the lower abdomen?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

---

2. Do you usually experience heaviness or dullness in the lower abdomen?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

---

3. Do you usually have a bulge or something falling out that you can see or fell in the vaginal area?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

4. Do you usually have to push on the vagina or around the rectum to have a complete bowel movement?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

5. Do you usually experience a feeling of incomplete bladder emptying?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

6. Do you ever have to push up in the vaginal area with your fingers to start or complete urination?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

7. Do you feel you need to strain too hard to have a bowel movement?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

8. Do you feel you have not completely emptied your bowels at the end of a bowel movement?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

9. Do you usually lose stool beyond your control if your stool is well formed?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

10. Do you usually lose stool beyond your control if your stool is loose or liquid?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

11. Do you usually lose gas from the rectum beyond your control?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

12. Do you usually have pain when you pass your stool?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

---

13. Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

---

14. Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

---

15. Do you usually experience frequent urination?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

---

16. Do you usually experience urine leakage associated with a feeling of urgency; that is, a strong sensation of needing to go to the bathroom?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

---

17. Do you usually experience urine leakage related to coughing, sneezing or laughing?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

---

18. Do you usually experience small amounts of urine leakage (drops)?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

---

19. Do you usually experience difficulty emptying your bladder?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

---

20. Do you usually experience pain or discomfort in the lower abdomen or genital region?

YES □ NO □

If Yes how much does this bother you?

1	2	3	4
Not at all	Somewhat	Moderately	Quite a bit

DATE AND TYPE (IF KNOWN) OF ANY BLADDER, BOWEL OR PELVIC FLOOR SURGERY YOU HAVE HAD.....

.....

.....

.....

.....

.....

Thank you for taking the time to complete this questionnaire

Appendix 5 - Questionnaire results correlated with proctographic findings

Pelvic organ prolapse symptoms

Q1 Do you usually experience pressure in the lower abdomen?			PD		
			PD<1.5	PD>1.5	Total
Q1	NO OR MINOR SYMPTOMS	Patient number	38	9	47
		%	80.9%	19.1%	100.0%
	CLEAR SYMPTOMS	Patient number	69	15	84
		%	82.1%	17.9%	100.0%
	Total	Patient number	107	24	131
		%	81.7%	18.3%	100.0%

Pearson Chi-square p=0.86

Q1 Do you usually experience pressure in the lower abdomen?			Rectocele		
			no rectocele	rectocele	Total
Q1	NO OR MINOR SYMPTOMS	Patient number	4	43	47
		%	8.5%	91.5%	100.0%
	CLEAR SYMPTOMS	Patient number	12	72	84
		%	14.3%	85.7%	100.0%
	Total	Patient number	16	115	131
		%	12.2%	87.8%	100.0%

Pearson Chi-square p=0.33

Q1 Do you usually experience pressure in the lower abdomen?			Size of rectocele (cm)		
			rectocele<2	rectocele2-4	Total
Q1	NO OR MINOR SYMPTOMS	Patient number	29	18	47
		%	61.7%	38.3%	100.0%
	CLEAR SYMPTOMS	Patient number	54	30	84
		%	64.3%	35.7%	100.0%
	Total	Patient number	83	48	131
		%	63.4%	36.6%	100.0%

Pearson Chi-square p=0.77

Q1 Do you usually experience pressure in the lower abdomen?			Rectal intussusception		
			no RI	RI	Total
Q1	NO OR MINOR SYMTOMS	Patient number	24	23	47
		%	51.1%	48.9%	100.0%
	CLEAR SYMPTOMS	Patient number	58	23	81
		%	71.6%	28.4%	100.0%
	Total	Patient number	82	46	128
		%	64.1%	35.9%	100.0%

Pearson Chi-square p=0.02*

Q1 Do you usually experience pressure in the lower abdomen?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q1	NO OR MINOR SYMTOMS	Count	24	0	10	5	8	0	47
		% within Q1	51.1%	.0%	21.3%	10.6%	17.0%	.0%	100.0 %
	CLEAR SYMPTOMS	Count	58	1	10	4	8	3	84
		% within Q1	69.0%	1.2%	11.9%	4.8%	9.5%	3.6%	100.0 %
	Total	Count	82	1	20	9	16	3	131
		% within Q1	62.6%	.8%	15.3%	6.9%	12.2%	2.3%	100.0 %

Pearson Chi-Square p=0.13
Linear-By-Association p=0.1

Q1 Do you usually experience pressure in the lower abdomen?			Rectal prolapse		
			no prolapse	prolapse	Total
Q1	NO OR MINOR SYMTOMS	Patient number	47	0	47
		%	100.0%	.0%	100.0%
	CLEAR SYMPTOMS	Patient number	81	3	84
		%	96.4%	3.6%	100.0%
	Total	Patient number	128	3	131
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.19

Q1 Do you usually experience pressure in the lower abdomen?			Enterocele		
			enterocele	no enterocele	Total
Q1	NO OR MINOR SYMTOMS	Patient number	7	40	47
		%	14.9%	85.1%	100.0%
	CLEAR SYMPTOMS	Patient number	9	75	84
		%	10.7%	89.3%	100.0%
	Total	Patient number	16	115	131
		%	12.2%	87.8%	100.0%

Pearson Chi-square p=0.48

Q1 Do you usually experience pressure in the lower abdomen?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q1	NO OR MINOR SYMTOMS	Patient number	2	45	47
		%	4.3%	95.7%	100.0%
	CLEAR SYMPTOMS	Patient number	6	78	84
		%	7.1%	92.9%	100.0%
	Total	Patient number	8	123	131
		%	6.1%	93.9%	100.0%

Pearson Chi-square p=0.51

Q2 Do you usually experience heaviness or dullness in the lower abdomen?			PD		
			PD<1.5	PD>1.5	Total
Q2	NO OR MINOR SYMPTOMS	Patient number	38	9	47
		%	80.9%	19.1%	100.0%
	CLEAR SYMPTOMS	Patient number	69	16	85
		%	81.2%	18.8%	100.0%
	Total	Patient number	107	25	132
		%	81.1%	18.9%	100.0%

Pearson Chi-square p=0.96

Q2 Do you usually experience heaviness or dullness in the lower abdomen?			Presence of rectocele		
			no rectocele	rectocele	Total
Q2	NO OR MINOR SYMPTOMS	Patient number	4	43	47
		%	8.5%	91.5%	100.0%
	CLEAR SYMPTOMS	Patient number	12	73	85
		%	14.1%	85.9%	100.0%
	Total	Patient number	16	116	132
		%	12.1%	87.9%	100.0%

Pearson Chi-square p=0.35

Q2 Do you usually experience heaviness or dullness in the lower abdomen?			Rectocele size (cm)		
			rectocele<2	rectocele2-4	Total
Q2	NO OR MINOR SYMPTOMS	Patient number	28	19	47
		%	59.6%	40.4%	100.0%
	CLEAR SYMPTOMS	Patient number	55	30	85
		%	64.7%	35.3%	100.0%
	Total	Patient number	83	49	132
		%	62.9%	37.1%	100.0%

Pearson Chi-square p=0.56

Q2 Do you usually experience heaviness or dullness in the lower abdomen?			Rectal intussusception		
			RI	No RI	Total
Q2	NO OR MINOR SYMPTOMS	Patient number	24	23	47
		%	51.1%	48.9%	100.0%
	CLEAR SYMPTOMS	Patient number	22	60	82
		%	26.8%	73.2%	100.0%
	Total	Patient number	46	83	129
		%	35.7%	64.3%	100.0%

Pearson Chi-square p=0.01*

Q2 Do you usually experience heaviness or dullness in the lower abdomen?			Grades of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q2	NO OR MINOR SYMPTOMS	Patient number	23	1	10	5	8	0	47
		%	48.9%	2.1%	21.3%	10.6%	17.0%	.0%	100.0 %
	CLEAR SYMPTOMS	Patient number	60	0	10	4	8	3	85
		%	70.6%	.0%	11.8%	4.7%	9.4%	3.5%	100.0 %
	Total	Patient number	83	1	20	9	16	3	132
		%	62.9%	.8%	15.2%	6.8%	12.1%	2.3%	100.0 %

Pearsons Chi-Square p=0.06

Linear-By-Linear Association p=0.07

Q2 Do you usually experience heaviness or dullness in the lower abdomen?			Rectal prolapse		
			no prolapse	prolapse	Total
Q2	NO OR MINOR SYMPTOMS	Patient number	47	0	47
		%	100.0%	.0%	100.0%
	CLEAR SYMPTOMS	Patient number	82	3	85
		%	96.5%	3.5%	100.0%
	Total	Patient number	129	3	132
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.19

Q2 Do you usually experience heaviness or dullness in the lower abdomen?			Enterocele		
			enterocele	no enterocele	Total
Q2	NO OR MINOR SYMPTOMS	Patient number	7	40	47
		%	14.9%	85.1%	100.0%
	CLEAR SYMPTOMS	Patient number	10	75	85
		%	11.8%	88.2%	100.0%
	Total	Patient number	17	115	132
		%	12.9%	87.1%	100.0%

Pearson Chi-square p=0.61

Q2 Do you usually experience heaviness or dullness in the lower abdomen?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q2	NO OR MINOR SYMPTOMS	Patient number	3	44	47
		%	6.4%	93.6%	100.0%
	CLEAR SYMPTOMS	Patient number	5	80	85
		%	5.9%	94.1%	100.0%
	Total	Patient number	8	124	132
		%	6.1%	93.9%	100.0%

Pearson Chi-square p=0.91

Q3 Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?			PD		
			PD<1.5	PD>1.5	Total
Q3	NO OR MINOR SYMPTOMS	Patient number	62	16	78
		%	79.5%	20.5%	100.0%
	CLEAR SYMPTOMS	Patient number	45	10	55
		%	81.8%	18.2%	100.0%
	Total	Patient number	107	26	133
		%	80.5%	19.5%	100.0%

Pearson Chi-square p=0.74

Q3 Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?			Presence of rectocele		
			no rectocele	rectocele	Total
Q3	NO OR MINOR SYMPTOMS	Patient number	11	67	78
		%	14.1%	85.9%	100.0%
	CLEAR SYMPTOMS	Patient number	5	50	55
		%	9.1%	90.9%	100.0%
	Total	Patient number	16	117	133
		%	12.0%	88.0%	100.0%

Pearson Chi-square p=0.38

Q3 Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?			Rectocele size (cm)		
			rectocele<2	rectocele2-4	Total
Q3	NO OR MINOR SYMPTOMS	Patient number	56	22	78
		%	71.8%	28.2%	100.0%
	CLEAR SYMPTOMS	Patient number	27	28	55
		%	49.1%	50.9%	100.0%
	Total	Patient number	83	50	133
		%	62.4%	37.6%	100.0%

Pearson Chi-square p=0.00*

Q3 Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?			Rectal intussusception		
			RI	No RI	Total
Q3	NO OR MINOR SYMPTOMS	Patient number	31	44	75
		%	41.3%	58.7%	100.0%
	CLEAR SYMPTOMS	Patient number	15	40	55
		%	27.3%	72.7%	100.0%
	Total	Patient number	46	84	130
		%	35.4%	64.6%	100.0%

Pearson Chi-square p=0.10

Q3 Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q3	NO OR NO SYMPTOMS	Patient number	44	0	14	5	12	3	78
		%	56.4%	.0%	17.9%	6.4%	15.4%	3.8%	100.0%
	CLEAR SYMTOMS	Patient number	40	1	6	4	4	0	55
		%	72.7%	1.8%	10.9%	7.3%	7.3%	.0%	100.0%
	Total	Patient number	84	1	20	9	16	3	133
		%	63.2%	.8%	15.0%	6.8%	12.0%	2.3%	100.0%

Pearsons Chi-Square p=0.17

Linear-By-Linear Association p=0.03*

Q3 Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?			Rectal prolapse		
			no prolapse	prolapse	Total
Q3	NO OR MINOR SYMPTOMS	Patient number	75	3	78
		%	96.2%	3.8%	100.0%
	CLEAR SYMPTOMS	Patient number	55	0	55
		%	100.0%	.0%	100.0%
	Total	Patient number	130	3	133
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.14

Q3 Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?			Enterocele		
			enterocele	no enterocele	Total
Q3	NO OR MINOR SYMPTOMS	Patient number	12	66	78
		%	15.4%	84.6%	100.0%
	CLEAR SYMPTOMS	Patient number	5	50	55
		%	9.1%	90.9%	100.0%
	Total	Patient number	17	116	133
		%	12.8%	87.2%	100.0%

Pearson Chi-square p=0.28

Q3 Do you usually have a bulge or something falling out that you can see or feel in the vaginal area?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q3	NO OR MINOR SYMPTOMS	Patient number	3	75	78
		%	3.8%	96.2%	100.0%
	CLEAR SYMPTOMS	Patient number	5	50	55
		%	9.1%	90.9%	100.0%
	Total	Patient number	8	125	133
		%	6.0%	94.0%	100.0%

Pearson Chi-square p=0.21

Q14 Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?			PD		
			PD<1.5	PD>1.5	Total
Q14	NO OR MINOR SYMPTOMS	Patient number	68	15	83
		%	81.9%	18.1%	100.0%
	CLEAR SYMPTOMS	Patient number	37	10	47
		%	78.7%	21.3%	100.0%
	Total	Patient number	105	25	130
		%	80.8%	19.2%	100.0%

Pearson Chi-square p=0.66

Q14 Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?			Rectocele		
			no rectocele	rectocele	Total
Q14	NO OR MINOR SYMPTOMS	Patient number	9	74	83
		%	10.8%	89.2%	100.0%
	CLEAR SYMPTOMS	Patient number	6	41	47
		%	12.8%	87.2%	100.0%
	Total	Patient number	15	115	130
		%	11.5%	88.5%	100.0%

Pearson Chi-square p=0.74

Q14 Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?			Rectocele size		
			rectocele<2	rectocele2-4	Total
Q14	NO OR MINOR SYMPTOMS	Patient number	49	34	83
		%	59.0%	41.0%	100.0%
	CLEAR SYMPTOMS	Patient number	32	15	47
		%	68.1%	31.9%	100.0%
	Total	Patient number	81	49	130
		%	62.3%	37.7%	100.0%

Pearson Chi-square p=0.31

Q14 Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?			Rectal intussusception		
			RI	No RI	Total
Q14	NO OR MINOR SYMPTOMS	Patient number	29	53	82
		%	35.4%	64.6%	100.0%
	CLEAR SYMPTOMS	Patient number	16	29	45
		%	35.6%	64.4%	100.0%
	Total	Patient number	45	82	127
		%	35.4%	64.6%	100.0%

Pearson Chi-square p=0.98

Q14 Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q14	NO OR MINOR SYMPTOMS	Patient number	53	0	17	5	7	1	83
		%	63.9%	.0%	20.5%	6.0%	8.4%	1.2%	100.0%
	CLEAR SYMPTOMS	Patient number	29	1	3	4	8	2	47
		%	61.7%	2.1%	6.4%	8.5%	17.0%	4.3%	100.0%
	Total	Patient number	82	1	20	9	15	3	130
		%	63.1%	.8%	15.4%	6.9%	11.5%	2.3%	100.0%

Pearsons Chi-Square p=0.10
Linear-By-Linear Association p=0.28

Q14 Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?			Rectal prolapse		
			no prolapse	prolapse	Total
Q14	NO OR MINOR SYMPTOMS	Patient number	82	1	83
		%	98.8%	1.2%	100.0%
	CLEAR SYMPTOMS	Patient number	45	2	47
		%	95.7%	4.3%	100.0%
	Total	Patient number	127	3	130
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.27

Q14 Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?			Enterocele		
			enterocele	no enterocele	Total
Q14	NO OR MINOR SYMPTOMS	Patient number	8	75	83
		%	9.6%	90.4%	100.0%
	CLEAR SYMPTOMS	Patient number	8	39	47
		%	17.0%	83.0%	100.0%
	Total	Patient number	16	114	130
		%	12.3%	87.7%	100.0%

Pearson Chi-square p=0.22

Q14 Does a part of your bowel ever pass through the rectum and bulge outside during or after a bowel movement?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q14	NO OR MINOR SYMPTOMS	Patient number	2	81	83
		%	2.4%	97.6%	100.0%
	CLEAR SYMPTOMS	Patient number	5	42	47
		%	10.6%	89.4%	100.0%
	Total	Patient number	7	123	130
		%	5.4%	94.6%	100.0%

Pearson Chi-square p=0.05*

Q20 Do you experience pain or discomfort in the lower abdomen or genital region?			PD		
			PD<1.5	PD>1.5	Total
Q20	NO OR MINOR SYMPTOMS	Patient number	52	13	65
		%	80.0%	20.0%	100.0%
	CLEAR SYMPTOMS	Patient number	54	13	67
		%	80.6%	19.4%	100.0%
	Total	Patient number	106	26	132
		%	80.3%	19.7%	100.0%

Pearson Chi-square p=0.93

Q20 Do you experience pain or discomfort in the lower abdomen or genital region?			Presence of rectocele		
			no rectocele	rectocele	Total
Q20	NO OR MINOR SYMPTOMS	Patient number	10	55	65
		%	15.4%	84.6%	100.0%
	CLEAR SYMPTOMS	Patient number	6	61	67
		%	9.0%	91.0%	100.0%
	Total	Patient number	16	116	132
		%	12.1%	87.9%	100.0%

Pearson Chi-square p=0.26

Q20 Do you experience pain or discomfort in the lower abdomen or genital region?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q20	NO OR MINOR SYMPTOMS	Patient number	41	24	65
		%	63.1%	36.9%	100.0%
	CLEAR SYMPTOMS	Patient number	42	25	67
		%	62.7%	37.3%	100.0%
	Total	Patient number	83	49	132
		%	62.9%	37.1%	100.0%

Pearson Chi-square p=0.96

Q20 Do you experience pain or discomfort in the lower abdomen or genital region?			Rectal intussusception		
			RI	No RI	Total
Q20	NO OR MINOR SYMPTOMS	Patient number	24	39	63
		%	38.1%	61.9%	100.0%
	CLEAR SYMPTOMS	Patient number	22	44	66
		%	33.3%	66.7%	100.0%
	Total	Patient number	46	83	129
		%	35.7%	64.3%	100.0%

Pearson Chi-square p=0.57

Q20 Do you experience pain or discomfort in the lower abdomen or genital region?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q20	NO OR MINOR SYMPTOMS	Patient number	39	0	11	4	9	2	65
		%	60.0%	.0%	16.9%	6.2%	13.8%	3.1%	100.0 %
	CLEAR SYMPTOMS	Patient number	44	1	9	5	7	1	67
		%	65.7%	1.5%	13.4%	7.5%	10.4%	1.5%	100.0 %
	Total	Patient number	83	1	20	9	16	3	132
		%	62.9%	.8%	15.2%	6.8%	12.1%	2.3%	100.0 %

Pearson Chi-Square p=0.83
Linear-By-Linear Association p=0.40

Q20 Do you experience pain or discomfort in the lower abdomen or genital region?			Rectal prolapse		
			no prolapse	prolapse	Total
Q20	NO OR MINOR SYMPTOMS	Patient number	63	2	65
		%	96.9%	3.1%	100.0%
	CLEAR SYMPTOMS	Patient number	66	1	67
		%	98.5%	1.5%	100.0%
	Total	Patient number	129	3	132
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.54

Q20 Do you experience pain or discomfort in the lower abdomen or genital region?			Enterocele		
			enterocele	no enterocele	Total
Q20	NO OR MINOR SYMPTOMS	Patient number	9	56	65
		%	13.8%	86.2%	100.0%
	CLEAR SYMPTOMS	Patient number	8	59	67
		%	11.9%	88.1%	100.0%
	Total	Patient number	17	115	132
		%	12.9%	87.1%	100.0%

Pearson Chi-square p=0.74

Q20 Do you experience pain or discomfort in the lower abdomen or genital region?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q20	NO OR MINOR SYMPTOMS	Patient number	4	61	65
		%	6.2%	93.8%	100.0%
	CLEAR SYMPTOMS	Patient number	4	63	67
		%	6.0%	94.0%	100.0%
	Total	Patient number	8	124	132
		%	6.1%	93.9%	100.0%

Pearson Chi-square p=0.97

Anorectal Dysfunction Symptoms

Q4 Do you usually have to push on the vagina or around the rectum to have a complete bowel movement?			PD		
			PD<1.5	PD>1.5	Total
Q4	NO OR MINOR SYMPTOMS	Patient number	31	9	40
		%	77.5%	22.5%	100.0%
	CLEAR SYMPTOMS	Patient number	72	17	89
		%	80.9%	19.1%	100.0%
	Total	Patient number	103	26	129
		%	79.8%	20.2%	100.0%

Pearson Chi-square p=0.66

Q4 Do you usually have to push on the vagina or around the rectum to have a complete bowel movement?			Presence of rectocele		
			no rectocele	rectocele	Total
Q4	NO OR MINOR SYMPTOMS	Patient number	6	34	40
		%	15.0%	85.0%	100.0%
	CLEAR SYMPTOMS	Patient number	9	80	89
		%	10.1%	89.9%	100.0%
	Total	Patient number	15	114	129
		%	11.6%	88.4%	100.0%

Pearson Chi-square p=0.42

Q4 Do you usually have to push on the vagina or around the rectum to have a complete bowel movement?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q4	NO OR MINOR SYMPTOMS	Patient number	28	12	40
		%	70.0%	30.0%	100.0%
	CLEAR SYMPTOMS	Patient number	53	36	89
		%	59.6%	40.4%	100.0%
	Total	Patient number	81	48	129
		%	62.8%	37.2%	100.0%

Pearson Chi-square p=0.26

Q4 Do you usually have to push on the vagina or around the rectum to have a complete bowel movement?			Rectal intussusception		
			RI	No RI	Total
Q4	NO OR MINOR SYMPTOMS	Patient number	13	25	38
		%	34.2%	65.8%	100.0%
	CLEAR SYMPTOMS	Patient number	31	57	88
		%	35.2%	64.8%	100.0%
	Total	Patient number	44	82	126
		%	34.9%	65.1%	100.0%

Pearson Chi-square p=0.91

Q4 Do you usually have to push on the vagina or around the rectum to have a complete bowel movement?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q4	NO OR MINOR SYMPTOMS	Patient number	25	0	4	2	7	2	40
		%	62.5%	.0%	10.0%	5.0%	17.5%	5.0%	100.0 %
	CLEAR SYMPTOMS	Patient number	57	1	16	6	8	1	89
		%	64.0%	1.1%	18.0%	6.7%	9.0%	1.1%	100.0 %
	Total	Patient number	82	1	20	8	15	3	129
		%	63.6%	.8%	15.5%	6.2%	11.6%	2.3%	100.0 %

Pearsons Chi-Square p=0.39
Linear-By-Linear Association p=0.30

Q4 Do you usually have to push on the vagina or around the rectum to have a complete bowel movement?			Rectal prolapse		
			no prolapse	prolapse	Total
Q4	NO OR MINOR SYMPTOMS	Patient number	38	2	40
		%	95.0%	5.0%	100.0%
	CLEAR SYMPTOMS	Patient number	88	1	89
		%	98.9%	1.1%	100.0%
	Total	Patient number	126	3	129
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.18

Q4 Do you usually have to push on the vagina or around the rectum to have a complete bowel movement? * Enterocele

			Enterocele		
			enterocele	no enterocele	Total
Q4	NO OR MINOR SYMPTOMS	Count	7	33	40
		% within Q4	17.5%	82.5%	100.0%
	CLEAR SYMPTOMS	Count	7	82	89
		% within Q4	7.9%	92.1%	100.0%
	Total	Count	14	115	129
		% within Q4	10.9%	89.1%	100.0%

Pearson Chi-square p=0.10

Q4 Do you usually have to push on the vagina or around the rectum to have a complete bowel movement?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q4	NO OR MINOR SYMPTOMS	Patient number	2	38	40
		%	5.0%	95.0%	100.0%
	CLEAR SYMPTOMS	Patient number	6	83	89
		%	6.7%	93.3%	100.0%
	Total	Patient number	8	121	129
		%	6.2%	93.8%	100.0%

Pearson Chi-square p=0.70

Q7 Do you feel you have to strain too hard to have a bowel movement?			PD		
			PD<1.5	PD>1.5	Total
Q7	NO OR MINOR SYMPTOMS	Patient number	23	3	26
		%	88.5%	11.5%	100.0%
	CLEAR SYMPTOMS	Patient number	79	23	102
		%	77.5%	22.5%	100.0%
	Total	Patient number	102	26	128
		%	79.7%	20.3%	100.0%

Pearson Chi-square p=0.21

Q7 Do you feel you have to strain too hard to have a bowel movement?			Presence of rectocele		
			no rectocele	rectocele	Total
Q7	NO OR MINOR SYMPTOMS	Patient number	2	24	26
		%	7.7%	92.3%	100.0%
	CLEAR SYMPTOMS	Patient number	13	89	102
		%	12.7%	87.3%	100.0%
	Total	Patient number	15	113	128
		%	11.7%	88.3%	100.0%

Pearson Chi-square p=0.76

Q7 Do you feel you have to strain too hard to have a bowel movement?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q7	NO OR MINOR SYMPTOMS	Patient number	14	12	26
		%	53.8%	46.2%	100.0%
	CLEAR SYMPTOMS	Patient number	67	35	102
		%	65.7%	34.3%	100.0%
	Total	Patient number	81	47	128
		%	63.3%	36.7%	100.0%

Pearson Chi-square p=0.26

Q7 Do you feel you have to strain too hard to have a bowel movement?			Rectal intussusception		
			RI	No RI	Total
Q7	NO OR MINOR SYMPTOMS	Patient number	14	12	26
		%	53.8%	46.2%	100.0%
	CLEAR SYMPTOMS	Patient number	30	69	99
		%	30.3%	69.7%	100.0%
	Total	Patient number	44	81	125
		%	35.2%	64.8%	100.0%

Pearson Chi-square p=0.03*

Q7 Do you feel you have to strain too hard to have a bowel movement?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q7	NO OR MINOR SYMPTOMS	Patient number	12	0	4	3	7	0	26
		%	46.2%	.0%	15.4%	11.5%	26.9%	.0%	100.0 %
	CLEAR SYMPTOMS	Patient number	69	1	15	5	9	3	102
		%	67.6%	1.0%	14.7%	4.9%	8.8%	2.9%	100.0 %
	Total	Patient number	81	1	19	8	16	3	128
		%	63.3%	.8%	14.8%	6.2%	12.5%	2.3%	100.0 %

Pearsons Chi-Square p=0.09
Linear-By-Linear Association p=0.03*

Q7 Do you feel you have to strain too hard to have a bowel movement?			Rectal prolapse		
			no prolapse	prolapse	Total
Q7	NO OR MINOR SYMPTOMS	Patient number	26	0	26
		%	100.0%	.0%	100.0%
	CLEAR SYMPTOMS	Patient number	99	3	102
		%	97.1%	2.9%	100.0%
	Total	Patient number	125	3	128
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.38

Q7 Do you feel you have to strain too hard to have a bowel movement?			Enterocele		
			enterocele	no enterocele	Total
Q7	NO OR MINOR SYMPTOMS	Patient number	4	22	26
		%	15.4%	84.6%	100.0%
	CLEAR SYMPTOMS	Patient number	10	92	102
		%	9.8%	90.2%	100.0%
	Total	Patient number	14	114	128
		%	10.9%	89.1%	100.0%

Pearson Chi-square p=0.42

Q7 Do you feel you have to strain too hard to have a bowel movement?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q7	NO OR MINOR SYMPTOMS	Patient number	1	25	26
		%	3.8%	96.2%	100.0%
	CLEAR SYMPTOMS	Patient number	7	95	102
		%	6.9%	93.1%	100.0%
	Total	Patient number	8	120	128
		%	6.2%	93.8%	100.0%

Pearson Chi-square p=0.57

Q8 Do you feel you have not completely emptied your bowels at the end of a bowel movement?			PD		
			PD<1.5	PD>1.5	Total
Q8	NO OR MINOR SYMPTOMS	Patient number	9	1	10
		%	90.0%	10.0%	100.0%
	CLEAR SYMPTOMS	Patient number	96	25	121
		%	79.3%	20.7%	100.0%
	Total	Patient number	105	26	131
		%	80.2%	19.8%	100.0%

Pearson Chi-square p=0.42

Q8 Do you feel you have not completely emptied your bowels at the end of a bowel movement?			Presence of rectocele		
			no rectocele	rectocele	Total
Q8	NO OR MINOR SYMPTOMS	Patient number	0	10	10
		%	.0%	100.0%	100.0%
	CLEAR SYMPTOMS	Patient number	16	105	121
		%	13.2%	86.8%	100.0%
	Total	Patient number	16	115	131
		%	12.2%	87.8%	100.0%

Pearson Chi-square p=0.22

Q8 Do you feel you have not completely emptied your bowels at the end of a bowel movement?			Size of rectocele (cm)		
			rectocele<2	rectocele2-4	Total
Q8	NO OR MINOR SYMPTOMS	Patient number	5	5	10
		%	50.0%	50.0%	100.0%
	CLEAR SYMPTOMS	Patient number	78	43	121
		%	64.5%	35.5%	100.0%
	Total	Patient number	83	48	131
		%	63.4%	36.6%	100.0%

Pearson Chi-square p= 0.36

Q8 Do you feel you have not completely emptied your bowels at the end of a bowel movement?			Rectal intussusception		
			RI	No RI	Total
Q8	NO OR MINOR SYMPTOMS	Patient number	4	6	10
		%	40.0%	60.0%	100.0%
	CLEAR SYMPTOMS	Patient number	41	77	118
		%	34.7%	65.3%	100.0%
	Total	Patient number	45	83	128
		%	35.2%	64.8%	100.0%

Pearson Chi-square p=0.74

Q8 Do you feel you have not completely emptied your bowels at the end of a bowel movement?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q8	NO OR MINOR SYMPTOMS	Patient number	6	0	0	2	2	0	10
		%	60.0%	.0%	.0%	20.0%	20.0%	.0%	100.0%
	CLEAR SYMPTOMS	Patient number	77	1	19	7	14	3	121
		%	63.6%	.8%	15.7%	5.8%	11.6%	2.5%	100.0%
	Total	Patient number	83	1	19	9	16	3	131
		%	63.4%	.8%	14.5%	6.9%	12.2%	2.3%	100.0%

Pearsons Chi-Square p=0.40
Linear-By-Linear Association p=0.54

Q8 Do you feel you have not completely emptied your bowels at the end of a bowel movement?			Rectal prolapse		
			no prolapse	prolapse	Total
Q8	NO OR MINOR SYMPTOMS	Patient number	10	0	10
		%	100.0%	.0%	100.0%
	CLEAR SYMPTOMS	Patient number	118	3	121
		%	97.5%	2.5%	100.0%
	Total	Patient number	128	3	131
		%	97.7%	2.3%	100.0%

Pearson Chi-square p= 0.61

Q8 Do you feel you have not completely emptied your bowels at the end of a bowel movement?			Enterocele		
			enterocele	no enterocele	Total
Q8	NO OR MINOR SYMPTOMS	Patient number	2	8	10
		%	20.0%	80.0%	100.0%
	CLEAR SYMPTOMS	Patient number	15	106	121
		%	12.4%	87.6%	100.0%
	Total	Patient number	17	114	131
		%	13.0%	87.0%	100.0%

Pearson Chi-square p=0.49

Q8 Do you feel you have not completely emptied your bowels at the end of a bowel movement?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q8	NO OR MINOR SYMPTOMS	Patient number	1	9	10
		%	10.0%	90.0%	100.0%
	CLEAR SYMPTOMS	Patient number	7	114	121
		%	5.8%	94.2%	100.0%
	Total	Patient number	8	123	131
		%	6.1%	93.9%	100.0%

Pearson Chi-square p=0.59

Q9 Do you usually lose stool beyond your control if your stool is well formed?			PD		
			PD<1.5	PD>1.5	Total
Q9	NO OR MINOR SYMPTOMS	Patient number	59	17	76
		%	77.6%	22.4%	100.0%
	CLEAR SYMPTOMS	Patient number	44	9	53
		%	83.0%	17.0%	100.0%
	Total	Patient number	103	26	129
		%	79.8%	20.2%	100.0%

Pearson Chi-square p=0.45

Q9 Do you usually lose stool beyond your control if your stool is well formed?			Presence of rectocele		
			no rectocele	rectocele	Total
Q9	NO OR MINOR SYMPTOMS	Patient number	7	69	76
		%	9.2%	90.8%	100.0%
	CLEAR SYMPTOMS	Patient number	9	44	53
		%	17.0%	83.0%	100.0%
	Total	Patient number	16	113	129
		%	12.4%	87.6%	100.0%

Pearson Chi-square p=0.19

Q9 Do you usually lose stool beyond your control if your stool is well formed?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q9	NO OR MINOR SYMPTOMS	Patient number	51	25	76
		%	67.1%	32.9%	100.0%
	CLEAR SYMPTOMS	Patient number	29	24	53
		%	54.7%	45.3%	100.0%
	Total	Patient number	80	49	129
		%	62.0%	38.0%	100.0%

Pearson Chi-square p=0.15
Linear-By-Linear Association p=0.16

Q9 Do you usually lose stool beyond your control if your stool is well formed?			Rectal intussusception		
			RI	No RI	Total
Q9	NO OR MINOR SYMPTOMS	Patient number	19	54	73
		%	26.0%	74.0%	100.0%
	CLEAR SYMPTOMS	Patient number	27	26	53
		%	50.9%	49.1%	100.0%
	Total	Patient number	46	80	126
		%	36.5%	63.5%	100.0%

Pearson Chi-square p=0.00*

Q9 Do you usually lose stool beyond your control if your stool is well formed?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q9	NO OR MINOR SYMPTOMS	Patient number	54	0	8	3	8	3	76
		%	71.1%	.0%	10.5%	3.9%	10.5%	3.9%	100.0%
	CLEAR SYMPTOMS	Patient number	26	1	12	6	8	0	53
		%	49.1%	1.9%	22.6%	11.3%	15.1%	.0%	100.0%
	Total	Patient number	80	1	20	9	16	3	129
		%	62.0%	.8%	15.5%	7.0%	12.4%	2.3%	100.0%

Pearsons Chi-Square p=0.04*
Linear-By-Linear Association p=0.10

Q9 Do you usually lose stool beyond your control if your stool is well formed?			Rectal prolapse		
			no prolapse	prolapse	Total
Q9	NO OR MINOR SYMPTOMS	Patient number	73	3	76
		%	96.1%	3.9%	100.0%
	CLEAR SYMPTOMS	Patient number	53	0	53
		%	100.0%	.0%	100.0%
	Total	Patient number	126	3	129
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.14

Q9 Do you usually lose stool beyond your control if your stool is well formed?			Enterocele		
			enterocele	no enterocele	Total
Q9	NO OR MINOR SYMPTOMS	Patient number	8	68	76
		%	10.5%	89.5%	100.0%
	CLEAR SYMPTOMS	Patient number	9	44	53
		%	17.0%	83.0%	100.0%
	Total	Patient number	17	112	129
		%	13.2%	86.8%	100.0%

Pearson Chi-square p=0.29

Q9 Do you usually lose stool beyond your control if your stool is well formed?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q9	NO OR MINOR SYMPTOMS	Patient number	5	71	76
		%	6.6%	93.4%	100.0%
	CLEAR SYMPTOMS	Patient number	2	51	53
		%	3.8%	96.2%	100.0%
	Total	Patient number	7	122	129
		%	5.4%	94.6%	100.0%

Pearson Chi-square p=0.49

Q10 Do you usually lose stool beyond your control if your stool is loose or liquid?			PD		
			PD<1.5	PD>1.5	Total
Q10	NO OR MINOR SYMPTOMS	Patient number	34	11	45
		%	75.6%	24.4%	100.0%
	CLEAR SYMPTOMS	Patient number	73	15	88
		%	83.0%	17.0%	100.0%
	Total	Patient number	107	26	133
		%	80.5%	19.5%	100.0%

Pearson Chi-square p=0.31

Q10 Do you usually lose stool beyond your control if your stool is loose or liquid?			Presence of rectocele		
			no rectocele	rectocele	Total
Q10	NO OR MINOR SYMPTOMS	Patient number	2	43	45
		%	4.4%	95.6%	100.0%
	CLEAR SYMPTOMS	Patient number	14	74	88
		%	15.9%	84.1%	100.0%
	Total	Patient number	16	117	133
		%	12.0%	88.0%	100.0%

Pearson Chi-square p=0.05*

Q10 Do you usually lose stool beyond your control if your stool is loose or liquid?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q10	NO OR MINOR SYMPTOMS	Patient number	29	16	45
		%	64.4%	35.6%	100.0%
	CLEAR SYMPTOMS	Patient number	54	34	88
		%	61.4%	38.6%	100.0%
	Total	Patient number	83	50	133
		%	62.4%	37.6%	100.0%

Pearson Chi-square p=0.73
Linear-By-Linear Association p=0.73

Q10 Do you usually lose stool beyond your control if your stool is loose or liquid?			Rectal intussusception		
			RI	No RI	Total
Q10	NO OR MINOR SYMPTOMS	Patient number	8	36	44
		%	18.2%	81.8%	100.0%
	CLEAR SYMPTOMS	Patient number	38	48	86
		%	44.2%	55.8%	100.0%
	Total	Patient number	46	84	130
		%	35.4%	64.6%	100.0%

Pearson Chi-square p=0.00*

Q10 Do you usually lose stool beyond your control if your stool is loose or liquid?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q10	NO OR MINOR SYMPTOMS	Patient number	36	0	4	2	2	1	45
		%	80.0%	.0%	8.9%	4.4%	4.4%	2.2%	100.0%
	CLEAR SYMPTOMS	Patient number	48	1	16	7	14	2	88
		%	54.5%	1.1%	18.2%	8.0%	15.9%	2.3%	100.0%
	Total	Patient number	84	1	20	9	16	3	133
		%	63.2%	.8%	15.0%	6.8%	12.0%	2.3%	100.0%

Pearsons Chi-Square p=0.11
linear-By-Linear Association p=0.01*

Q10 Do you usually lose stool beyond your control if your stool is loose or liquid?			Rectal prolapse		
			no prolapse	prolapse	Total
Q10	NO OR MINOR SYMPTOMS	Patient number	44	1	45
		%	97.8%	2.2%	100.0%
	CLEAR SYMPTOMS	Patient number	86	2	88
		%	97.7%	2.3%	100.0%
	Total	Patient number	130	3	133
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.99

Q10 Do you usually lose stool beyond your control if your stool is loose or liquid?			Enterocele		
			enterocele	no enterocele	Total
Q10	NO OR MINOR SYMPTOMS	Patient number	5	40	45
		%	11.1%	88.9%	100.0%
	CLEAR SYMPTOMS	Patient number	12	76	88
		%	13.6%	86.4%	100.0%
	Total	Patient number	17	116	133
		%	12.8%	87.2%	100.0%

Pearson Chi-square p=0.68

Q10 Do you usually lose stool beyond your control if your stool is loose or liquid?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q10	NO OR MINOR SYMPTOMS	Patient number	3	42	45
		%	6.7%	93.3%	100.0%
	CLEAR SYMPTOMS	Patient number	5	83	88
		%	5.7%	94.3%	100.0%
	Total	Patient number	8	125	133
		%	6.0%	94.0%	100.0%

Pearson Chi-square p=0.82

Q11 Do you usually lose gas from the rectum beyond your control?			PD		
			PD<1.5	PD>1.5	Total
Q11	NO OR MINOR SYMPTOMS	Patient number	22	10	32
		%	68.8%	31.2%	100.0%
	CLEAR SYMPTOMS	Patient number	85	16	101
		%	84.2%	15.8%	100.0%
	Total	Patient number	107	26	133
		%	80.5%	19.5%	100.0%

Pearson Chi-square p=0.06

Q11 Do you usually lose gas from the rectum beyond your control?			Rectocele		
			no rectocele	rectocele	Total
Q11	NO OR MINOR SYMPTOMS	Patient number	3	29	32
		%	9.4%	90.6%	100.0%
	CLEAR SYMPTOMS	Patient number	13	88	101
		%	12.9%	87.1%	100.0%
	Total	Patient number	16	117	133
		%	12.0%	88.0%	100.0%

Pearson Chi-square p=0.60

Q11 Do you usually lose gas from the rectum beyond your control?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q11	NO OR MINOR SYMPTOMS	Patient number	17	15	32
		%	53.1%	46.9%	100.0%
	CLEAR SYMPTOMS	Patient number	66	35	101
		%	65.3%	34.7%	100.0%
	Total	Patient number	83	50	133
		%	62.4%	37.6%	100.0%

Pearson Chi-square p=0.21

Q11 Do you usually lose gas from the rectum beyond your control?			Rectal intussusception		
			RI	No RI	Total
Q11	NO OR MINOR SYMPTOMS	Patient number	6	26	32
		%	18.8%	81.2%	100.0%
	CLEAR SYMPTOMS	Patient number	40	58	98
		%	40.8%	59.2%	100.0%
	Total	Patient number	46	84	130
		%	35.4%	64.6%	100.0%

Pearson Chi-square p=0.02*

Q11 Do you usually lose gas from the rectum beyond your control?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q11	NO OR MINOR SYMPTOMS	Patient number	26	0	3	0	3	0	32
		%	81.2%	.0%	9.4%	.0%	9.4%	.0%	100.0%
	CLEAR SYMPTOMS	Patient number	58	1	17	9	13	3	101
		%	57.4%	1.0%	16.8%	8.9%	12.9%	3.0%	100.0%
	Total	Patient number	84	1	20	9	16	3	133
		%	63.2%	.8%	15.0%	6.8%	12.0%	2.3%	100.0%

Pearsons Chi-Square p=0.19
Linear-By-Linear Association p=0.03*

Q11 Do you usually lose gas from the rectum beyond your control?			Rectal prolapse		
			no prolapse	prolapse	Total
Q11	NO OR MINOR SYMPTOMS	Patient number	32	0	32
		%	100.0%	.0%	100.0%
	CLEAR SYMPTOMS	Patient number	98	3	101
		%	97.0%	3.0%	100.0%
	Total	Patient number	130	3	133
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.32

Q11 Do you usually lose gas from the rectum beyond your control?			Enterocele		
			enterocele	no enterocele	Total
Q11	NO OR MINOR SYMPTOMS	Patient number	5	27	32
		%	15.6%	84.4%	100.0%
	CLEAR SYMPTOMS	Patient number	12	89	101
		%	11.9%	88.1%	100.0%
	Total	Patient number	17	116	133
		%	12.8%	87.2%	100.0%

Pearson Chi-square p=0.58

Q11 Do you usually lose gas from the rectum beyond your control?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q11	NO OR MINOR SYMPTOMS	Patient number	2	30	32
		%	6.2%	93.8%	100.0%
	CLEAR SYMPTOMS	Patient number	6	95	101
		%	5.9%	94.1%	100.0%
	Total	Patient number	8	125	133
		%	6.0%	94.0%	100.0%

Pearson Chi-square p=0.95

Q12 Do you usually have pain when you pass your stool?			PD		
			PD<1.5	PD>1.5	Total
Q12	NO OR MINOR SYMPTOMS	Patient number	52	13	65
		%	80.0%	20.0%	100.0%
	CLEAR SYMPTOMS	Patient number	55	13	68
		%	80.9%	19.1%	100.0%
	Total	Patient number	107	26	133
		%	80.5%	19.5%	100.0%

Pearson Chi-square p=0.90

Q12 Do you usually have pain when you pass your stool?			Presence of rectocele		
			no rectocele	rectocele	Total
Q12	NO OR MINOR SYMPTOMS	Patient number	8	57	65
		%	12.3%	87.7%	100.0%
	CLEAR SYMPTOMS	Patient number	8	60	68
		%	11.8%	88.2%	100.0%
	Total	Patient number	16	117	133
		%	12.0%	88.0%	100.0%

Pearson Chi-square p=0.92

Q12 Do you usually have pain when you pass your stool?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q12	NO OR MINOR SYMPTOMS	Patient number	41	24	65
		%	63.1%	36.9%	100.0%
	CLEAR SYMPTOMS	Patient number	42	26	68
		%	61.8%	38.2%	100.0%
	Total	Patient number	83	50	133
		%	62.4%	37.6%	100.0%

Pearson Chi-square p=0.88
Linear-By-Linear Association p=0.88

Q12 Do you usually have pain when you pass your stool?			Rectal intussusception		
			RI	No RI	Total
Q12	NO OR MINOR SYMPTOMS	Patient number	25	38	63
		%	39.7%	60.3%	100.0%
	CLEAR SYMPTOMS	Patient number	21	46	67
		%	31.3%	68.7%	100.0%
	Total	Patient number	46	84	130
		%	35.4%	64.6%	100.0%

Pearson Chi-square p=0.32

Q12 Do you usually have pain when you pass your stool?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q12	NO OR MINOR SYMPTOMS	Patient number	38	1	9	4	11	2	65
		%	58.5%	1.5%	13.8%	6.2%	16.9%	3.1%	100.0%
	CLEAR SYMPTOMS	Patient number	46	0	11	5	5	1	68
		%	67.6%	.0%	16.2%	7.4%	7.4%	1.5%	100.0%
	Total	Patient number	84	1	20	9	16	3	133
		%	63.2%	.8%	15.0%	6.8%	12.0%	2.3%	100.0%

Pearsons Chi-Square p=0.47
Linear-By-Linear Association p=0.15

Q12 Do you usually have pain when you pass your stool?			Rectal prolapse		
			no prolapse	prolapse	Total
Q12	NO OR MINOR SYMPTOMS	Patient number	63	2	65
		%	96.9%	3.1%	100.0%
	CLEAR SYMPTOMS	Patient number	67	1	68
		%	98.5%	1.5%	100.0%
	Total	Patient number	130	3	133
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.53

Q12 Do you usually have pain when you pass your stool?			Enterocele		
			enterocele	no enterocele	Total
Q12	NO OR MINOR SYMPTOMS	Patient number	8	57	65
		%	12.3%	87.7%	100.0%
	CLEAR SYMPTOMS	Patient number	9	59	68
		%	13.2%	86.8%	100.0%
	Total	Patient number	17	116	133
		%	12.8%	87.2%	100.0%

Pearson Chi-square p=0.87

Q12 Do you usually have pain when you pass your stool?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q12	NO OR MINOR SYMPTOMS	Patient number	5	60	65
		%	7.7%	92.3%	100.0%
	CLEAR SYMPTOMS	Patient number	3	65	68
		%	4.4%	95.6%	100.0%
	Total	Patient number	8	125	133
		%	6.0%	94.0%	100.0%

Pearson Chi-square p=0.43

Q13 Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?			PD		
			PD<1.5	PD>1.5	Total
Q13	NO OR MINOR SYMPTOMS	Patient number	37	10	47
		%	78.7%	21.3%	100.0%
	CLEAR SYMPTOMS	Patient number	70	16	86
		%	81.4%	18.6%	100.0%
	Total	Patient number	107	26	133
		%	80.5%	19.5%	100.0%

Pearson Chi-square p=0.71

Q13 Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?			Presence of rectocele		
			no rectocele	rectocele	Total
Q13	NO OR MINOR SYMPTOMS	Patient number	3	44	47
		%	6.4%	93.6%	100.0%
	CLEAR SYMPTOMS	Patient number	13	73	86
		%	15.1%	84.9%	100.0%
	Total	Patient number	16	117	133
		%	12.0%	88.0%	100.0%

Pearson Chi-square p=0.14

Q13 Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q13	NO OR MINOR SYMPTOMS	Patient number	25	22	47
		%	53.2%	46.8%	100.0%
	CLEAR SYMPTOMS	Patient number	58	28	86
		%	67.4%	32.6%	100.0%
	Total	Patient number	83	50	133
		%	62.4%	37.6%	100.0%

Pearson Chi-square p=0.11
Linear-By-Linear Association p=0.11

Q13 Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?			Rectal intussusception		
			RI	No RI	Total
Q13	NO OR MINOR SYMPTOMS	Patient number	10	37	47
		%	21.3%	78.7%	100.0%
	CLEAR SYMPTOMS	Patient number	36	47	83
		%	43.4%	56.6%	100.0%
	Total	Patient number	46	84	130
		%	35.4%	64.6%	100.0%

Pearson Chi-square p=0.01*

Q13 Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q13	NO OR MINOR SYMPTOMS	Patient number	37	1	6	1	2	0	47
		%	78.7%	2.1%	12.8%	2.1%	4.3%	.0%	100.0%
	CLEAR SYMPTOMS	Patient number	47	0	14	8	14	3	86
		%	54.7%	.0%	16.3%	9.3%	16.3%	3.5%	100.0%
	Total	Patient number	84	1	20	9	16	3	133
		%	63.2%	.8%	15.0%	6.8%	12.0%	2.3%	100.0%

Pearsons Chi-Square p=0.03*
Linear-By-Linear Association p=0.00*

Q13 Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?			Rectal prolapse		
			no prolapse	prolapse	Total
Q13	NO OR MINOR SYMPTOMS	Patient number	47	0	47
		%	100.0%	.0%	100.0%
	CLEAR SYMPTOMS	Patient number	83	3	86
		%	96.5%	3.5%	100.0%
	Total	Patient number	130	3	133
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.20

Q13 Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?			Enterocele		
			enterocele	no enterocele	Total
Q13	NO OR MINOR SYMPTOMS	Patient number	4	43	47
		%	8.5%	91.5%	100.0%
	CLEAR SYMPTOMS	Patient number	13	73	86
		%	15.1%	84.9%	100.0%
	Total	Patient number	17	116	133
		%	12.8%	87.2%	100.0%

Pearson Chi-square p=0.28

Q13 Do you experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q13	NO OR MINOR SYMPTOMS	Patient number	3	44	47
		%	6.4%	93.6%	100.0%
	CLEAR SYMPTOMS	Patient number	5	81	86
		%	5.8%	94.2%	100.0%
	Total	Patient number	8	125	133
		%	6.0%	94.0%	100.0%

Pearson Chi-square p=0.90

Urinary Dysfunction

Q5 Do you usually experience a feeling of incomplete bladder emptying?			PD		
			PD<1.5	PD>1.5	Total
Q5	NO OR MINOR SYMPTOMS	Patient number	49	9	58
		%	84.5%	15.5%	100.0%
	CLEAR SYMPTOMS	Patient number	56	17	73
		%	76.7%	23.3%	100.0%
	Total	Patient number	105	26	131
		%	80.2%	19.8%	100.0%

Pearson Chi-square p=0.27

Q5 Do you usually experience a feeling of incomplete bladder emptying?			Presence of rectocele		
			no rectocele	rectocele	Total
Q5	NO OR MINOR SYMPTOMS	Patient number	7	51	58
		%	12.1%	87.9%	100.0%
	CLEAR SYMPTOMS	Patient number	9	64	73
		%	12.3%	87.7%	100.0%
	Total	Patient number	16	115	131
		%	12.2%	87.8%	100.0%

Pearson Chi-square p=0.96

Q5 Do you usually experience a feeling of incomplete bladder emptying?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q5	NO OR MINOR SYMPTOMS	Patient number	36	22	58
		%	62.1%	37.9%	100.0%
	CLEAR SYMPTOMS	Patient number	46	27	73
		%	63.0%	37.0%	100.0%
	Total	Patient number	82	49	131
		%	62.6%	37.4%	100.0%

Pearson Chi-square p=0.91
Linear-By-Linear Association p=0.91

Q5 Do you usually experience a feeling of incomplete bladder emptying?			Rectal intussusception		
			RI	No RI	Total
Q5	NO OR MINOR SYMPTOMS	Patient number	24	33	57
		%	42.1%	57.9%	100.0%
	CLEAR SYMPTOMS	Patient number	22	49	71
		%	31.0%	69.0%	100.0%
	Total	Patient number	46	82	128
		%	35.9%	64.1%	100.0%

Pearson Chi-square p=0.19

Q5 Do you usually experience a feeling of incomplete bladder emptying?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q5	NO OR MINOR SYMPTOMS	Patient number	33	0	9	3	12	1	58
		%	56.9%	.0%	15.5%	5.2%	20.7%	1.7%	100.0%
	CLEAR SYMPTOMS	Patient number	49	1	11	6	4	2	73
		%	67.1%	1.4%	15.1%	8.2%	5.5%	2.7%	100.0%
	Total	Patient number	82	1	20	9	16	3	131
		%	62.6%	.8%	15.3%	6.9%	12.2%	2.3%	100.0%

Pearsons Chi-Square p=0.15
Linear-By-Linear Association p=0.10

Q5 Do you usually experience a feeling of incomplete bladder emptying?			Rectal prolapse		
			no prolapse	prolapse	Total
Q5	NO OR MINOR SYMPTOMS	Patient number	57	1	58
		%	98.3%	1.7%	100.0%
	CLEAR SYMPTOMS	Patient number	71	2	73
		%	97.3%	2.7%	100.0%
	Total	Patient number	128	3	131
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.70

Q5 Do you usually experience a feeling of incomplete bladder emptying?			Enterocele		
			enterocele	no enterocele	Total
Q5	NO OR MINOR SYMPTOMS	Patient number	6	52	58
		%	10.3%	89.7%	100.0%
	CLEAR SYMPTOMS	Patient number	11	62	73
		%	15.1%	84.9%	100.0%
	Total	Patient number	17	114	131
		%	13.0%	87.0%	100.0%

Pearson Chi-square p=0.42

Q5 Do you usually experience a feeling of incomplete bladder emptying?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q5	NO OR MINOR SYMPTOMS	Patient number	2	56	58
		%	3.4%	96.6%	100.0%
	CLEAR SYMPTOMS	Patient number	6	67	73
		%	8.2%	91.8%	100.0%
	Total	Patient number	8	123	131
		%	6.1%	93.9%	100.0%

Pearson Chi-square p=0.26

Q6 Do you ever have to push up in the vaginal area with your fingers to start or complete urination?			PD		
			PD<1.5	PD>1.5	Total
Q6	NO OR CLEAR SYMPTOMS	Patient number	97	25	122
		%	79.5%	20.5%	100.0%
	CLEAR SYMPTOMS	Patient number	7	0	7
		%	100.0%	.0%	100.0%
	Total	Patient number	104	25	129
		%	80.6%	19.4%	100.0%

Pearson Chi-square p=0.18

Q6 Do you ever have to push up in the vaginal area with your fingers to start or complete urination?			Presence of rectocele		
			no rectocele	rectocele	Total
Q6	NO OR CLEAR SYMPTOMS	Patient number	15	107	122
		%	12.3%	87.7%	100.0%
	CLEAR SYMPTOMS	Patient number	1	6	7
		%	14.3%	85.7%	100.0%
	Total	Patient number	16	113	129
		%	12.4%	87.6%	100.0%

Pearsons Chi-square p=0.88

Q6 Do you ever have to push up in the vaginal area with your fingers to start or complete urination?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q6	NO OR CLEAR SYMPTOMS	Patient number	79	43	122
		%	64.8%	35.2%	100.0%
	CLEAR SYMPTOMS	Patient number	4	3	7
		%	57.1%	42.9%	100.0%
	Total	Patient number	83	46	129
		%	64.3%	35.7%	100.0%

Pearsons Chi-square p=0.68
Linear-By-Linear Association p=0.68

Q6 Do you ever have to push up in the vaginal area with your fingers to start or complete urination?			Rectal intussusception		
			RI	No RI	Total
Q6	NO OR CLEAR SYMPTOMS	Patient number	41	78	119
		%	34.5%	65.5%	100.0%
	CLEAR SYMPTOMS	Patient number	4	3	7
		%	57.1%	42.9%	100.0%
	Total	Patient number	45	81	126
		%	35.7%	64.3%	100.0%

Pearsons Chi-square p=0.22

Q6 Do you ever have to push up in the vaginal area with your fingers to start or complete urination?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q6	NO OR CLEAR SYMPTOMS	Patient number	78	1	16	9	15	3	122
		%	63.9%	.8%	13.1%	7.4%	12.3%	2.5%	100.0%
	CLEAR SYMPTOMS	Patient number	3	0	3	0	1	0	7
		%	42.9%	.0%	42.9%	.0%	14.3%	.0%	100.0%
	Total	Patient number	81	1	19	9	16	3	129
		%	62.8%	.8%	14.7%	7.0%	12.4%	2.3%	100.0%

Pearsons Chi-Square p=0.39
Linear-By-Linear Association p=0.60

Q6 Do you ever have to push up in the vaginal area with your fingers to start or complete urination?			Rectal prolapse		
			no prolapse	prolapse	Total
Q6	NO OR CLEAR SYMPTOMS	Patient number	119	3	122
		%	97.5%	2.5%	100.0%
	CLEAR SYMPTOMS	Patient number	7	0	7
		%	100.0%	.0%	100.0%
	Total	Patient number	126	3	129
		%	97.7%	2.3%	100.0%

Pearsons Chi-square p=0.68

Q6 Do you ever have to push up in the vaginal area with your fingers to start or complete urination?			Enterocele		
			enterocele	no enterocele	Total
Q6	NO OR CLEAR SYMPTOMS	Patient number	17	105	122
		%	13.9%	86.1%	100.0%
	CLEAR SYMPTOMS	Patient number	0	7	7
		%	.0%	100.0%	100.0%
	Total	Patient number	17	112	129
		%	13.2%	86.8%	100.0%

Pearsons Chi-square p=0.29

Q6 Do you ever have to push up in the vaginal area with your fingers to start or complete urination?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q6	NO OR CLEAR SYMPTOMS	Patient number	6	116	122
		%	4.9%	95.1%	100.0%
	CLEAR SYMPTOMS	Patient number	1	6	7
		%	14.3%	85.7%	100.0%
	Total	Patient number	7	122	129
		%	5.4%	94.6%	100.0%

Pearsons Chi-square p=0.29

Q15 Do you usually experience frequent urination?			PD		
			PD<1.5	PD>1.5	Total
Q15	NO OR MINOR SYMPTOMS	Patient number	44	12	56
		%	78.6%	21.4%	100.0%
	CLEAR SYMPTOMS	Patient number	62	13	75
		%	82.7%	17.3%	100.0%
	Total	Patient number	106	25	131
		%	80.9%	19.1%	100.0%

Pearsons Chi-square p=0.56

Q15 Do you usually experience frequent urination?			Presence of rectocele		
			no rectocele	rectocele	Total
Q15	NO OR MINOR SYMPTOMS	Patient number	9	47	56
		%	16.1%	83.9%	100.0%
	CLEAR SYMPTOMS	Patient number	6	69	75
		%	8.0%	92.0%	100.0%
	Total	Patient number	15	116	131
		%	11.5%	88.5%	100.0%

Pearsons Chi-square p=0.15

Q15 Do you usually experience frequent urination?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q15	NO OR MINOR SYMPTOMS	Patient number	38	18	56
		%	67.9%	32.1%	100.0%
	CLEAR SYMPTOMS	Patient number	44	31	75
		%	58.7%	41.3%	100.0%
	Total	Patient number	82	49	131
		%	62.6%	37.4%	100.0%

Pearsons Chi-square p=0.28
Linear-By-Linear Association p=0.28

Q15 Do you usually experience frequent urination?			Rectal intussusception		
			RI	No RI	Total
Q15	NO OR MINOR SYMPTOMS	Patient number	23	31	54
		%	42.6%	57.4%	100.0%
	CLEAR SYMPTOMS	Patient number	23	51	74
		%	31.1%	68.9%	100.0%
	Total	Patient number	46	82	128
		%	35.9%	64.1%	100.0%

Pearsons Chi-square p=0.18

Q15 Do you usually experience frequent urination?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q15	NO OR MINOR SYMPTOMS	Patient number	31	0	11	2	10	2	56
		%	55.4%	.0%	19.6%	3.6%	17.9%	3.6%	100.0%
	CLEAR SYMPTOMS	Patient number	51	1	9	7	6	1	75
		%	68.0%	1.3%	12.0%	9.3%	8.0%	1.3%	100.0%
	Total	Patient number	82	1	20	9	16	3	131
		%	62.6%	.8%	15.3%	6.9%	12.2%	2.3%	100.0%

Pearsons Chi-Square p=0.18
Linear-By-Linear Association p=0.09

Q15 Do you usually experience frequent urination?			Rectal prolapse		
			no prolapse	prolapse	Total
Q15	NO OR MINOR SYMPTOMS	Patient number	54	2	56
		%	96.4%	3.6%	100.0%
	CLEAR SYMPTOMS	Patient number	74	1	75
		%	98.7%	1.3%	100.0%
	Total	Patient number	128	3	131
		%	97.7%	2.3%	100.0%

Pearsons Chi-square p=0.40

Q15 Do you usually experience frequent urination?			Enterocele		
			enterocele	no enterocele	Total
Q15	NO OR MINOR SYMPTOMS	Patient number	6	50	56
		%	10.7%	89.3%	100.0%
	CLEAR SYMPTOMS	Patient number	11	64	75
		%	14.7%	85.3%	100.0%
	Total	Patient number	17	114	131
		%	13.0%	87.0%	100.0%

Pearsons Chi-square p=0.51

Q15 Do you usually experience frequent urination?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q15	NO OR MINOR SYMPTOMS	Patient number	3	53	56
		%	5.4%	94.6%	100.0%
	CLEAR SYMPTOMS	Patient number	5	70	75
		%	6.7%	93.3%	100.0%
	Total	Patient number	8	123	131
		%	6.1%	93.9%	100.0%

Pearsons Chi-square p=0.76

Q16 Do you usually experience urine leakage associated with a feeling of urgency; that is, a strong sensation of needing to go to the bathroom?			PD		
			PD<1.5	PD>1.5	Total
Q16	NO OR MINOR SYMPTOMS	Patient number	56	18	74
		%	75.7%	24.3%	100.0%
	CLEAR SYMPTOMS	Patient number	50	8	58
		%	86.2%	13.8%	100.0%
	Total	Patient number	106	26	132
		%	80.3%	19.7%	100.0%

Pearson Chi-square p=0.13

Q16 Do you usually experience urine leakage associated with a feeling of urgency; that is, a strong sensation of needing to go to the bathroom?			Rectocele		
			no rectocele	rectocele	Total
Q16	NO OR MINOR SYMPTOMS	Patient number	11	63	74
		%	14.9%	85.1%	100.0%
	CLEAR SYMPTOMS	Patient number	5	53	58
		%	8.6%	91.4%	100.0%
	Total	Patient number	16	116	132
		%	12.1%	87.9%	100.0%

Pearson Chi-square p=0.28

Q16 Do you usually experience urine leakage associated with a feeling of urgency; that is, a strong sensation of needing to go to the bathroom?			Size of Rectocele		
			rectocele<2	rectocele2-4	Total
Q16	NO OR MINOR SYMPTOMS	Patient number	49	25	74
		%	66.2%	33.8%	100.0%
	CLEAR SYMPTOMS	Patient number	34	24	58
		%	58.6%	41.4%	100.0%
	Total	Patient number	83	49	132
		%	62.9%	37.1%	100.0%

Pearson Chi-square p=0.37

Q16 Do you usually experience urine leakage associated with a feeling of urgency; that is, a strong sensation of needing to go to the bathroom?			Rectal intussusception		
			RI	No RI	Total
Q16	NO OR MINOR SYMPTOMS	Patient number	28	43	71
		%	39.4%	60.6%	100.0%
	CLEAR SYMPTOMS	Patient number	18	40	58
		%	31.0%	69.0%	100.0%
	Total	Patient number	46	83	129
		%	35.7%	64.3%	100.0%

Pearson Chi-square p=0.32

Q16 Do you usually experience urine leakage associated with a feeling of urgency; that is, a strong sensation of needing to go to the bathroom?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q16	NO OR MINOR SYMPTOMS	Patient number	43	1	14	3	10	3	74
		%	58.1%	1.4%	18.9%	4.1%	13.5%	4.1%	100.0%
	CLEAR SYMPTOMS	Patient number	40	0	6	6	6	0	58
		%	69.0%	.0%	10.3%	10.3%	10.3%	.0%	100.0%
	Total	Patient number	83	1	20	9	16	3	132
		%	62.9%	.8%	15.2%	6.8%	12.1%	2.3%	100.0%

Pearsons Chi-Square p=0.19
Linear-By-Linear Association p=0.18

Q16 Do you usually experience urine leakage associated with a feeling of urgency; that is, a strong sensation of needing to go to the bathroom?			Rectal prolapse		
			no prolapse	prolapse	Total
Q16	NO OR MINOR SYMPTOMS	Patient number	71	3	74
		%	95.9%	4.1%	100.0%
	CLEAR SYMPTOMS	Patient number	58	0	58
		%	100.0%	.0%	100.0%
	Total	Patient number	129	3	132
		%	97.7%	2.3%	100.0%

Pearson Chi-square p=0.12

Q16 Do you usually experience urine leakage associated with a feeling of urgency; that is, a strong sensation of needing to go to the bathroom?			Enterocele		
			enterocele	no enterocele	Total
Q16	NO OR MINOR SYMPTOMS	Patient number	9	65	74
		%	12.2%	87.8%	100.0%
	CLEAR SYMPTOMS	Patient number	8	50	58
		%	13.8%	86.2%	100.0%
	Total	Patient number	17	115	132
		%	12.9%	87.1%	100.0%

Pearson Chi-square p=0.78

Q16 Do you usually experience urine leakage associated with a feeling of urgency; that is, a strong sensation of needing to go to the bathroom?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q16	NO OR MINOR SYMPTOMS	Patient number	5	69	74
		%	6.8%	93.2%	100.0%
	CLEAR SYMPTOMS	Patient number	3	55	58
		%	5.2%	94.8%	100.0%
	Total	Patient number	8	124	132
		%	6.1%	93.9%	100.0%

Pearson Chi-square p=0.71

Q17 Do you usually experience urine leakage related to coughing, sneezing or laughing?			PD		
			PD<1.5	PD>1.5	Total
Q17	NO OR MINOR SYMPTOMS	Patient number	50	14	64
		%	78.1%	21.9%	100.0%
	CLEAR SYMPTOMS	Patient number	56	11	67
		%	83.6%	16.4%	100.0%
	Total	Patient number	106	25	131
		%	80.9%	19.1%	100.0%

Pearson Chi-square p=0.43

Q17 Do you usually experience urine leakage related to coughing, sneezing or laughing?			Presence of rectocele		
			no rectocele	rectocele	Total
Q17	NO OR MINOR SYMPTOMS	Patient number	9	55	64
		%	14.1%	85.9%	100.0%
	CLEAR SYMPTOMS	Patient number	7	60	67
		%	10.4%	89.6%	100.0%
	Total	Patient number	16	115	131
		%	12.2%	87.8%	100.0%

Pearsons Chi-square p=0.53

Q17 Do you usually experience urine leakage related to coughing, sneezing or laughing?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q17	NO OR MINOR SYMPTOMS	Patient number	39	25	64
		%	60.9%	39.1%	100.0%
	CLEAR SYMPTOMS	Patient number	44	23	67
		%	65.7%	34.3%	100.0%
	Total	Patient number	83	48	131
		%	63.4%	36.6%	100.0%

Pearsons Chi-square p=0.57
Linear-By-Linear Association p=0.58

Q17 Do you usually experience urine leakage related to coughing, sneezing or laughing?			Rectal intussusception		
			RI	No RI	Total
Q17	NO OR MINOR SYMPTOMS	Patient number	24	38	62
		%	38.7%	61.3%	100.0%
	CLEAR SYMPTOMS	Patient number	22	44	66
		%	33.3%	66.7%	100.0%
	Total	Patient number	46	82	128
		%	35.9%	64.1%	100.0%

Pearsons Chi-square p=0.53

Q17 Do you usually experience urine leakage related to coughing, sneezing or laughing?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q17	NO OR MINOR SYMPTOMS	Patient number	38	1	8	3	12	2	64
		%	59.4%	1.6%	12.5%	4.7%	18.8%	3.1%	100.0%
	CLEAR SYMPTOMS	Patient number	44	0	12	6	4	1	67
		%	65.7%	.0%	17.9%	9.0%	6.0%	1.5%	100.0%
	Total	Patient number	82	1	20	9	16	3	131
		%	62.6%	.8%	15.3%	6.9%	12.2%	2.3%	100.0%

Pearsons Chi-Square p=0.19
Linear-By-Linear Association p=0.18

Q17 Do you usually experience urine leakage related to coughing, sneezing or laughing?			Rectal prolapse		
			no prolapse	prolapse	Total
Q17	NO OR MINOR SYMPTOMS	Patient number	62	2	64
		%	96.9%	3.1%	100.0%
	CLEAR SYMPTOMS	Patient number	66	1	67
		%	98.5%	1.5%	100.0%
	Total	Patient number	128	3	131
		%	97.7%	2.3%	100.0%

Pearsons Chi-square p=0.53

Q17 Do you usually experience urine leakage related to coughing, sneezing or laughing?			Enterocele		
			enterocele	no enterocele	Total
Q17	NO OR MINOR SYMPTOMS	Patient number	9	55	64
		%	14.1%	85.9%	100.0%
	CLEAR SYMPTOMS	Patient number	7	60	67
		%	10.4%	89.6%	100.0%
	Total	Patient number	16	115	131
		%	12.2%	87.8%	100.0%

Pearsons Chi-square p=0.53

Q17 Do you usually experience urine leakage related to coughing, sneezing or laughing?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q17	NO OR MINOR SYMPTOMS	Patient number	5	59	64
		%	7.8%	92.2%	100.0%
	CLEAR SYMPTOMS	Patient number	3	64	67
		%	4.5%	95.5%	100.0%
	Total	Patient number	8	123	131
		%	6.1%	93.9%	100.0%

Pearsons Chi-square p=0.43

Q18 Do you usually experience small amounts of urine leakage (drops)?			PD		
			PD<1.5	PD>1.5	Total
Q18	NO OR MINOR SYMPTOMS	Patient number	58	12	70
		%	82.9%	17.1%	100.0%
	CLEAR SYMPTOMS	Patient number	46	14	60
		%	76.7%	23.3%	100.0%
	Total	Patient number	104	26	130
		%	80.0%	20.0%	100.0%

Pearsons Chi-square p=0.38

Q18 Do you usually experience small amounts of urine leakage (drops)?			Presence of rectocele		
			no rectocele	rectocele	Total
Q18	NO OR MINOR SYMPTOMS	Patient number	7	63	70
		%	10.0%	90.0%	100.0%
	CLEAR SYMPTOMS	Patient number	9	51	60
		%	15.0%	85.0%	100.0%
	Total	Patient number	16	114	130
		%	12.3%	87.7%	100.0%

Pearsons Chi-square p=0.39

Q18 Do you usually experience small amounts of urine leakage (drops)?			Size of rectocele		
			rectocele <2	rectocele2-4	Total
Q18	NO OR MINOR SYMPTOMS	Patient number	38	32	70
		%	54.3%	45.7%	100.0%
	CLEAR SYMPTOMS	Patient number	43	17	60
		%	71.7%	28.3%	100.0%
	Total	Patient number	81	49	130
		%	62.3%	37.7%	100.0%

Pearsons Chi-square p=0.04*
Linear-By-Linear Association p=0.04*

Q18 Do you usually experience small amounts of urine leakage (drops)?			Rectal intussusception		
			RI	No RI	Total
Q18	NO OR MINOR SYMPTOMS	Patient number	23	45	68
		%	33.8%	66.2%	100.0%
	CLEAR SYMPTOMS	Patient number	23	36	59
		%	39.0%	61.0%	100.0%
	Total	Patient number	46	81	127
		%	36.2%	63.8%	100.0%

Pearsons Chi-square p=0.55

Q18 Do you usually experience small amounts of urine leakage (drops)?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q18	NO OR MINOR SYMPTOMS	Patient number	45	1	8	4	10	2	70
		%	64.3%	1.4%	11.4%	5.7%	14.3%	2.9%	100.0%
	CLEAR SYMPTOMS	Patient number	36	0	12	5	6	1	60
		%	60.0%	.0%	20.0%	8.3%	10.0%	1.7%	100.0%
	Total	Patient number	81	1	20	9	16	3	130
		%	62.3%	.8%	15.4%	6.9%	12.3%	2.3%	100.0%

Pearsons Chi-Square p=0.62
Linear-By-Linear Association p=0.99

Q18 Do you usually experience small amounts of urine leakage (drops)?			Rectal prolapse		
			no prolapse	prolapse	Total
Q18	NO OR MINOR SYMPTOMS	Patient number	68	2	70
		%	97.1%	2.9%	100.0%
	CLEAR SYMPTOMS	Patient number	59	1	60
		%	98.3%	1.7%	100.0%
	Total	Patient number	127	3	130
		%	97.7%	2.3%	100.0%

Pearsons Chi-square p=0.65

Q18 Do you usually experience small amounts of urine leakage (drops)?			Enterocele		
			enterocele	no enterocele	Total
Q18	NO OR MINOR SYMPTOMS	Patient number	10	60	70
		%	14.3%	85.7%	100.0%
	CLEAR SYMPTOMS	Patient number	7	53	60
		%	11.7%	88.3%	100.0%
	Total	Patient number	17	113	130
		%	13.1%	86.9%	100.0%

Pearsons Chi-square p=0.66

Q18 Do you usually experience small amounts of urine leakage (drops)?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q18	NO OR MINOR SYMPTOMS	Patient number	2	68	70
		%	2.9%	97.1%	100.0%
	CLEAR SYMPTOMS	Patient number	5	55	60
		%	8.3%	91.7%	100.0%
	Total	Patient number	7	123	130
		%	5.4%	94.6%	100.0%

Pearsons Chi-square p=0.17

Q19 Do you usually experience difficulty emptying your bladder?			PD		
			PD<1.5	PD>1.5	Total
Q19	NO OR MINOR SYMPTOMS	Patient number	77	17	94
		%	81.9%	18.1%	100.0%
	CLEAR SYMPTOMS	Patient number	29	9	38
		%	76.3%	23.7%	100.0%
	Total	Patient number	106	26	132
		%	80.3%	19.7%	100.0%

Pearsons Chi-square p=0.46

Q19 Do you usually experience difficulty emptying your bladder?			Presence of rectocele		
			no rectocele	rectocele	Total
Q19	NO OR MINOR SYMPTOMS	Patient number	9	85	94
		%	9.6%	90.4%	100.0%
	CLEAR SYMPTOMS	Patient number	7	31	38
		%	18.4%	81.6%	100.0%
	Total	Patient number	16	116	132
		%	12.1%	87.9%	100.0%

Pearsons Chi-square p=0.16

Q19 Do you usually experience difficulty emptying your bladder?			Size of rectocele		
			rectocele<2	rectocele2-4	Total
Q19	NO OR MINOR SYMPTOMS	Patient number	55	39	94
		%	58.5%	41.5%	100.0%
	CLEAR SYMPTOMS	Patient number	28	10	38
		%	73.7%	26.3%	100.0%
	Total	Patient number	83	49	132
		%	62.9%	37.1%	100.0%

Pearsons Chi-square p=0.10
Linear-By-Linear Association p=0.10

Q19 Do you usually experience difficulty emptying your bladder?			Rectal intussusception		
			RI	No RI	Total
Q19	NO OR MINOR SYMPTOMS	Patient number	40	52	92
		%	43.5%	56.5%	100.0%
	CLEAR SYMPTOMS	Patient number	6	31	37
		%	16.2%	83.8%	100.0%
	Total	Patient number	46	83	129
		%	35.7%	64.3%	100.0%

Pearsons Chi-square p=0.00*

Q19 Do you usually experience difficulty emptying your bladder?			Grade of rectal intussusception						
			no RI	1	2	3	4	5	Total
Q19	NO OR MINOR SYMPTOMS	Patient number	52	1	16	8	15	2	94
		%	55.3%	1.1%	17.0%	8.5%	16.0%	2.1%	100.0%
	CLEAR SYMPTOMS	Patient number	31	0	4	1	1	1	38
		%	81.6%	.0%	10.5%	2.6%	2.6%	2.6%	100.0%
	Total	Patient number	83	1	20	9	16	3	132
		%	62.9%	.8%	15.2%	6.8%	12.1%	2.3%	100.0%

Pearsons Chi-Square p=0.09
Linear-By-Linear Association p=0.01*

Q19 Do you usually experience difficulty emptying your bladder?			Rectal prolapse		
			no prolapse	prolapse	Total
Q19	NO OR MINOR SYMPTOMS	Patient number	92	2	94
		%	97.9%	2.1%	100.0%
	CLEAR SYMPTOMS	Patient number	37	1	38
		%	97.4%	2.6%	100.0%
	Total	Patient number	129	3	132
		%	97.7%	2.3%	100.0%

Pearsons Chi-square p=0.86

Q19 Do you usually experience difficulty emptying your bladder?			Enterocele		
			enterocele	no enterocele	Total
Q19	NO OR MINOR SYMPTOMS	Patient number	8	86	94
		%	8.5%	91.5%	100.0%
	CLEAR SYMPTOMS	Patient number	9	29	38
		%	23.7%	76.3%	100.0%
	Total	Patient number	17	115	132
		%	12.9%	87.1%	100.0%

Pearsons Chi-square p=0.02*

Q19 Do you usually experience difficulty emptying your bladder?			Lateral rectocele		
			lateral rectocele	no lateral rectocele	Total
Q19	NO OR MINOR SYMPTOMS	Patient number	6	88	94
		%	6.4%	93.6%	100.0%
	CLEAR SYMPTOMS	Patient number	2	36	38
		%	5.3%	94.7%	100.0%
	Total	Patient number	8	124	132
		%	6.1%	93.9%	100.0%

Pearsons Chi-square p=0.81

References

1. Vesalius, A., *De humani corporis fabrica libri septem* 1543, Basel: Joannis Oporini
2. Gray, H., *Gray's Anatomy*. 38th ed, ed. P.L. Williams. 1995: Churchill Livingstone.
3. Lien, K.-C., et al., *Pudendal nerve stretch during vaginal birth: A 3D computer simulation.* American Journal of Obstetrics and Gynecology, 2005. **192**(5): p. 1669-1676.
4. Parks, A.G., N.H. Porter, and J. Melzak, *Experimental study of the reflex mechanism controlling the muscle of the pelvic floor.* Dis Colon Rectum, 1962. **5**: p. 407-14.
5. Ashton-Miller, J.A. and J.O. DeLancey, *Functional anatomy of the female pelvic floor.* Ann N Y Acad Sci, 2007. **1101**: p. 266-96.
6. Frenckner, B. and T. Ihre, *Influence of autonomic nerves on the internal and sphincter in man.* Gut, 1976. **17**(4): p. 306-312.
7. Guyton AC, H.J., *Textbook of Medical Physiology*. 9th ed. 1994: Saunders.
8. Milligan, E., Morgan CN, Jones LE, Officer R, *Surgical anatomy of the anal canal and the operative treatment of haemorrhoids.* The Lancet, 1937. **230**(5959): p. 1119-1124.
9. Goligher, J.C., A.G. Leacock, and J.J. Brossy, *The surgical anatomy of the anal canal.* Br J Surg, 1955. **43**(177): p. 51-61.
10. Ayoub, S.F., *Anatomy of the external anal sphincter in man.* Acta Anat (Basel), 1979. **105**(1): p. 25-36.
11. Bollard, R.C., et al., *Normal female anal sphincter: difficulties in interpretation explained.* Dis Colon Rectum, 2002. **45**(2): p. 171-5.
12. Beersiek, F., A.G. Parks, and M. Swash, *Pathogenesis of ano-rectal incontinence. A histometric study of the anal sphincter musculature.* J Neurol Sci, 1979. **42**(1): p. 111-27.
13. Lunniss, P.J. and R.K.S. Phillips, *Anatomy and function of the anal longitudinal muscle.* British Journal of Surgery, 1992. **79**(9): p. 882-884.
14. Lawson, J.O., *Pelvic anatomy. II. Anal canal and associated sphincters.* Ann R Coll Surg Engl, 1974. **54**(6): p. 288-300.
15. Gibbons, C.P., et al., *ROLE OF ANAL CUSHIONS IN MAINTAINING CONTINENCE.* The Lancet, 1986. **327**(8486): p. 886-888.
16. Raizada, V. and R.K. Mittal, *Pelvic Floor Anatomy and Applied Physiology.* Gastroenterology Clinics of North America, 2008. **37**(3): p. 493-509.
17. Gowers, W.R., *The Automatic Action of the Sphincter Ani.* Proceedings of the Royal Society of London, 1877. **26**: p. 77-84.
18. Miller, R., et al., *Anorectal sampling: A comparison of normal and incontinent patients.* British Journal of Surgery, 1988. **75**(1): p. 44-47.
19. Shafik, A., *A concept of the anatomy of the anal sphincter mechanism and the physiology of defecation.* Dis Colon Rectum, 1987. **30**(12): p. 970-82.

20. Marcio J, J.N., *History, clinical examination and basic physiology*, in *Complex Anorectal Disorders*, Z.A. Wexner S, Pescatori M, Editor. 2005, Springer-Verlag: London. p. 18-38.
21. Chatoor, D.R., et al., *Faecal incontinence.* Br J Surg, 2007. **94**(2): p. 134-44.
22. Lawson, J.O. and H.H. Nixon, *Anal canal pressures in the diagnosis of Hirschsprung's disease.* J Pediatr Surg, 1967. **2**(6): p. 544-52.
23. Rao, S.S., et al., *Manometric tests of anorectal function in healthy adults.* Am J Gastroenterol, 1999. **94**(3): p. 773-83.
24. Lestar, B., F. Penninckx, and R. Kerremans, *The composition of anal basal pressure. An in vivo and in vitro study in man.* Int J Colorectal Dis, 1989. **4**(2): p. 118-22.
25. Preston, D.M. and J.E. Lennard-Jones, *Anismus in chronic constipation.* Dig Dis Sci, 1985. **30**(5): p. 413-8.
26. Ramachandran, G.N. and G. Kartha, *Structure of Collagen.* Nature, 1955. **176**(4482): p. 593-595.
27. Bailey, A.J., R.G. Paul, and L. Knott, *Mechanisms of maturation and ageing of collagen.* Mechanisms of Ageing and Development, 1998. **106**(1â€“2): p. 1-56.
28. Stevens, A.a.L., James S, *Human Histology*. 2 ed, ed. L. Cook. 1997: Mosby.
29. Kerkhof, M.H., L. Hendriks, and H.A. Brolmann, *Changes in connective tissue in patients with pelvic organ prolapse--a review of the current literature.* Int Urogynecol J Pelvic Floor Dysfunct, 2009. **20**(4): p. 461-74.
30. Norton, P.A., *Pelvic floor disorders: the role of fascia and ligaments.* Clin Obstet Gynecol, 1993. **36**(4): p. 926-38.
31. Mott, J.D. and Z. Werb, *Regulation of matrix biology by matrix metalloproteinases.* Curr Opin Cell Biol, 2004. **16**(5): p. 558-64.
32. Bailey, A.J., *Molecular mechanisms of ageing in connective tissues.* Mechanisms of Ageing and Development, 2001. **122**(7): p. 735-755.
33. Kokcu, A., et al., *Histopathological evaluation of the connective tissue of the vaginal fascia and the uterine ligaments in women with and without pelvic relaxation.* Arch Gynecol Obstet, 2002. **266**(2): p. 75-8.
34. Kim, B.S., A. Atala, and J.J. Yoo, *A collagen matrix derived from bladder can be used to engineer smooth muscle tissue.* World J Urol, 2008. **26**(4): p. 307-14.
35. Takano, C.C., et al., *Analysis of collagen in parametrium and vaginal apex of women with and without uterine prolapse.* Int Urogynecol J Pelvic Floor Dysfunct, 2002. **13**(6): p. 342-5; discussion 345.
36. Wallner, C., et al., *The Anatomical Components of Urinary Continence.* European Urology, 2009. **55**(4): p. 932-944.
37. Stegemann, H. and K. Stalder, *Determination of hydroxyproline.* Clin Chim Acta, 1967. **18**(2): p. 267-73.
38. Jackson, S.R., et al., *Changes in metabolism of collagen in genitourinary prolapse.* Lancet, 1996. **347**(9016): p. 1658-61.
39. Bornstein, P. and H. Sage, *Structurally distinct collagen types.* Annu Rev Biochem, 1980. **49**: p. 957-1003.
40. Gabriel, B., et al., *Uterosacral ligament in postmenopausal women with or without pelvic organ prolapse.* Int Urogynecol J Pelvic Floor Dysfunct, 2005. **16**(6): p. 475-9.

41. Moalli, P.A., et al., *Impact of menopause on collagen subtypes in the arcus tendineous fasciae pelvis.* Am J Obstet Gynecol, 2004. **190**(3): p. 620-7.
42. Ewies, A.A., F. Al-Azzawi, and J. Thompson, *Changes in extracellular matrix proteins in the cardinal ligaments of post-menopausal women with or without prolapse: a computerized immunohistomorphometric analysis.* Hum Reprod, 2003. **18**(10): p. 2189-95.
43. Bird, H.A., *Joint hypermobility.* Musculoskeletal Care, 2007. **5**(1): p. 4-19.
44. Beighton, P., et al., *Ehlers-Danlos syndromes: Revised nosology, Villefranche, 1997.* American Journal of Medical Genetics, 1998. **77**(1): p. 31-37.
45. Hayward, C. and D.J. Brock, *Fibrillin-1 mutations in Marfan syndrome and other type-1 fibrillinopathies.* Hum Mutat, 1997. **10**(6): p. 415-23.
46. Parry, D.A., A.S. Craig, and G.R. Barnes, *Tendon and ligament from the horse: an ultrastructural study of collagen fibrils and elastic fibres as a function of age.* Proc R Soc Lond B Biol Sci, 1978. **203**(1152): p. 293-303.
47. Bailey, A.J., R.G. Paul, and L. Knott, *Mechanisms of maturation and ageing of collagen.* Mech Ageing Dev, 1998. **106**(1-2): p. 1-56.
48. DeLancey, J.O., *Anatomic aspects of vaginal eversion after hysterectomy.* Am J Obstet Gynecol, 1992. **166**(6 Pt 1): p. 1717-24; discussion 1724-8.
49. DeLancey, J.O., *Structural anatomy of the posterior pelvic compartment as it relates to rectocele.* Am J Obstet Gynecol, 1999. **180**(4): p. 815-23.
50. Milley, P.S. and D.H. Nichols, *A correlative investigation of the human rectovaginal septum.* Anat Rec, 1969. **163**(3): p. 443-51.
51. Richardson, A.C., *The rectovaginal septum revisited: its relationship to rectocele and its importance in rectocele repair.* Clin Obstet Gynecol, 1993. **36**(4): p. 976-83.
52. Parks, A.G., N.H. Porter, and J. Hardcastle, *The syndrome of the descending perineum.* Proc R Soc Med, 1966. **59**(6): p. 477-82.
53. Read NW, B.J., *Anorectal manometry:techniques in health and anorectal disease,* in *Coloproctology and the Pelvic Floor,* S.M. Henry M, Editor. 1985, Butterworths: London. p. 65-87.
54. Hardcastle, J.D. and A.G. Parks, *A study of anal incontinence and some principles of surgical treatment.* Proc R Soc Med, 1970. **63 Suppl**: p. 116-8.
55. Parks, A.G., *Royal Society of Medicine, Section of Proctology; Meeting 27 November 1974. President's Address. Anorectal incontinence.* Proc R Soc Med, 1975. **68**(11): p. 681-90.
56. Henry, M.M. and J.N. Simson, *Results of postanal repair: a retrospective study.* Br J Surg, 1985. **72 Suppl**: p. S17-9.
57. Yoshioka, K. and M.R. Keighley, *Critical assessment of the quality of continence after postanal repair for faecal incontinence.* Br J Surg, 1989. **76**(10): p. 1054-7.
58. Scheuer, M., H.C. Kuijpers, and P.P. Jacobs, *Postanal repair restores anatomy rather than function.* Dis Colon Rectum, 1989. **32**(11): p. 960-3.
59. Laurberg, S., M. Swash, and M.M. Henry, *Effect of postanal repair on progress of neurogenic damage to the pelvic floor.* Br J Surg, 1990. **77**(5): p. 519-22.
60. Jameson, J.S., et al., *Audit of postanal repair in the treatment of fecal incontinence.* Dis Colon Rectum, 1994. **37**(4): p. 369-72.

61. Kiff, E.S. and M. Swash, *Slowed conduction in the pudendal nerves in idiopathic (neurogenic) faecal incontinence.* Br J Surg, 1984. **71**(8): p. 614-6.
62. Henry, M.M., A.G. Parks, and M. Swash, *The pelvic floor musculature in the descending perineum syndrome.* Br J Surg, 1982. **69**(8): p. 470-2.
63. Lubowski, D.Z., et al., *Increase in pudendal nerve terminal motor latency with defaecation straining.* Br J Surg, 1988. **75**(11): p. 1095-7.
64. Jones, P.N., et al., *Relation between perineal descent and pudendal nerve damage in idiopathic faecal incontinence.* Int J Colorectal Dis, 1987. **2**(2): p. 93-5.
65. Ho, Y.H. and H.S. Goh, *The neurophysiological significance of perineal descent.* Int J Colorectal Dis, 1995. **10**(2): p. 107-11.
66. Jorge, J.M., et al., *Does perineal descent correlate with pudendal neuropathy?* Dis Colon Rectum, 1993. **36**(5): p. 475-83.
67. Snooks, S.J., M.M. Henry, and M. Swash, *Anorectal incontinence and rectal prolapse: differential assessment of the innervation to puborectalis and external anal sphincter muscles.* Gut, 1985. **26**(5): p. 470-476.
68. Goei, R., *Anorectal function in patients with defecation disorders and asymptomatic subjects: evaluation with defecography.* Radiology, 1990. **174**(1): p. 121-123.
69. Savoyeâ€ Collet, C.l., et al., *Defecography in symptomatic older women living at home.* Age and Ageing, 2003. **32**(3): p. 347-350.
70. Harewood, G.C., et al., *Descending perineum syndrome: audit of clinical and laboratory features and outcome of pelvic floor retraining.* Am J Gastroenterol, 1999. **94**(1): p. 126-30.
71. Broekhuis, S.R., et al., *Perineal descent and patients' symptoms of anorectal dysfunction, pelvic organ prolapse, and urinary incontinence.* Int Urogynecol J Pelvic Floor Dysfunct. **21**(6): p. 721-9.
72. Oettle, G.J., et al., *What is the best way of measuring perineal descent? A comparison of radiographic and clinical methods.* Br J Surg, 1985. **72**(12): p. 999-1001.
73. Wallden, L., *Defecation block in cases of deep rectogenital pouch.* Acta Chir Scand, 1952. **103**(3): p. 236-8.
74. Burhenne, H.J., *Intestinal Evacuation Study: A New Roentgenologic Technique.* Radiol Clin, 1964. **33**: p. 79-84.
75. Broden, B. and B. Snellman, *Procidentia of the rectum studied with cineradiography. A contribution to the discussion of causative mechanism.* Dis Colon Rectum, 1968. **11**(5): p. 330-47.
76. Mahieu, P., J. Pringot, and P. Bodart, *Defecography: I. Description of a new procedure and results in normal patients.* Gastrointest Radiol, 1984. **9**(3): p. 247-51.
77. Mahieu, P., J. Pringot, and P. Bodart, *Defecography: II. Contribution to the diagnosis of defecation disorders.* Gastrointest Radiol, 1984. **9**(3): p. 253-61.
78. Ekberg, O., G. Nylander, and F.T. Fork, *Defecography.* Radiology, 1985. **155**(1): p. 45-8.
79. Skomorowska, E., V. Hegedus, and J. Christiansen, *Evaluation of perineal descent by defaecography.* Int J Colorectal Dis, 1988. **3**(4): p. 191-4.

80. Selvaggi, F., et al., *Evaluation of normal subjects by defecographic technique.* Dis Colon Rectum, 1990. **33**(8): p. 698-702.
81. Felt-Bersma, R.J., et al., *Defecography in patients with anorectal disorders. Which findings are clinically relevant?* Dis Colon Rectum, 1990. **33**(4): p. 277-84.
82. Preston, D.M., J.E. Lennard-Jones, and B.M. Thomas, *The balloon proctogram.* Br J Surg, 1984. **71**(1): p. 29-32.
83. Choi, J.S., et al., *Intraobserver and interobserver measurements of the anorectal angle and perineal descent in defecography.* Dis Colon Rectum, 2000. **43**(8): p. 1121-6.
84. Jorge, J.M., A. Habr-Gama, and S.D. Wexner, *Clinical applications and techniques of cinedefecography.* Am J Surg, 2001. **182**(1): p. 93-101.
85. Bartolo, D.C., A.M. Roe, and N.J. Mortensen, *The relationship between perineal descent and denervation of the puborectalis in continent patients.* Int J Colorectal Dis, 1986. **1**(2): p. 91-5.
86. Shorvon, P.J., et al., *Defecography in normal volunteers: results and implications.* Gut, 1989. **30**(12): p. 1737-49.
87. Devadhar, D.S.C.M.S.F.R.C.S.a., *A new concept of mechanism and treatment of rectal procidentia.* Diseases of the Colon & Rectum, 1965. **8**(1): p. 75-77.
88. Broden, B.M.D. and B.M.D. Snellman, *Procidentia of the rectum studied with cineradiography: A contribution to the discussion of causative mechanism.* SO - Diseases of the Colon & Rectum September/October 1968;11(5):330-347.
89. Mellgren, A., et al., *Internal rectal intussusception seldom develops into total rectal prolapse.* Dis Colon Rectum, 1997. **40**(7): p. 817-20.
90. Choi, J.S., et al., *Outcome and management of patients with large rectoanal intussusception.* Am J Gastroenterol, 2001. **96**(3): p. 740-4.
91. Wijffels, N.A., et al., *What Is the Natural History of Internal Rectal Prolapse ?* Colorectal Dis, 2009.
92. D'Hoore, A., R. Cadoni, and F. Penninckx, *Long-term outcome of laparoscopic ventral rectopexy for total rectal prolapse.* British Journal of Surgery, 2004. **91**(11): p. 1500-1505.
93. Pomerri, F., et al., *Defecographic measurements of rectal intussusception and prolapse in patients and in asymptomatic subjects.* AJR Am J Roentgenol, 2001. **176**(3): p. 641-5.
94. Dvorkin, L.S., et al., *Rectal intussusception in symptomatic patients is different from that in asymptomatic volunteers.* Br J Surg, 2005. **92**(7): p. 866-72.
95. Dietz, H.P. and A. Korda, *Which bowel symptoms are most strongly associated with a s rectocele?* Australian and New Zealand Journal of Obstetrics and Gynaecology, 2005. **45**(6): p. 505-508.
96. Collinson, R., et al., *Rectal intussusception and unexplained faecal incontinence: findings of a proctographic study.* Colorectal Dis, 2009. **11**(1): p. 77-83.
97. Thompson, J.R., et al., *Incidence of occult rectal prolapse in patients with clinical rectoceles and defecatory dysfunction.* American Journal of Obstetrics and Gynecology, 2002. **187**(6): p. 1494-1500.

98. Mellgren, A., et al., *Enterocele demonstrated by defaecography is associated with other pelvic floor disorders.* International Journal of Colorectal Disease, 1994. **9**(3): p. 121-124.
99. Olsen, A.L. and S.S.C. Rao, *CLINICAL NEUROPHYSIOLOGY AND ELECTRODIAGNOSTIC TESTING OF THE PELVIC FLOOR.* Gastroenterology Clinics of North America, 2001. **30**(1): p. 33-54.
100. Ricciardi, R., et al., *The utility of pudendal nerve terminal motor latencies in idiopathic incontinence.* Dis Colon Rectum, 2006. **49**(6): p. 852-7.
101. Suilleabhain, C.B., et al., *The relationship of pudendal nerve terminal motor latency to squeeze pressure in patients with idiopathic fecal incontinence.* Dis Colon Rectum, 2001. **44**(5): p. 666-71.
102. Thomas, C., et al., *Respective value of pudendal nerve terminal motor latency and anal sphincter electromyography in neurogenic fecal incontinence.* Neurophysiol Clin, 2002. **32**(1): p. 85-90.
103. Lefaucheur, J.P., *Neurophysiological testing in anorectal disorders.* Muscle Nerve, 2006. **33**(3): p. 324-33.
104. Hill, J., G. Hosker, and E.S. Kiff, *Pudendal nerve terminal motor latency measurements: what they do and do not tell us.* Br J Surg, 2002. **89**(10): p. 1268-9.
105. Lubowski, D.Z., et al., *Asymmetrical pudendal nerve damage in pelvic floor disorders.* Int J Colorectal Dis, 1988. **3**(3): p. 158-60.
106. Fowler, A.L., et al., *Single-fiber electromyography correlates more closely with incontinence scores than pudendal nerve terminal motor latency.* Dis Colon Rectum, 2005. **48**(12): p. 2309-12.
107. Henry, M.M., *Neurophysiological assessment of the pelvic floor.* Gut, 1988. **29**(1): p. 1-4.
108. Snooks, S.J., et al., *Injury to innervation of pelvic floor sphincter musculature in childbirth.* Lancet, 1984. **2**(8402): p. 546-50.
109. Neill, M.E. and M. Swash, *Increased motor unit fibre density in the external anal sphincter muscle in ano-rectal incontinence: a single fibre EMG study.* J Neurol Neurosurg Psychiatry, 1980. **43**(4): p. 343-7.
110. Kiff, E.S. and M. Swash, *Normal proximal and delayed distal conduction in the pudendal nerves of patients with idiopathic (neurogenic) faecal incontinence.* J Neurol Neurosurg Psychiatry, 1984. **47**(8): p. 820-3.
111. Law, P.J. and C.I. Bartram, *Anal endosonography: technique and normal anatomy.* Gastrointest Radiol, 1989. **14**(4): p. 349-53.
112. Deen, K.I., et al., *Anal sphincter defects. Correlation between endoanal ultrasound and surgery.* Ann Surg, 1993. **218**(2): p. 201-5.
113. Fucini, C., O. Ronchi, and C. Elbetti, *Electromyography of the pelvic floor musculature in the assessment of obstructed defecation symptoms.* Dis Colon Rectum, 2001. **44**(8): p. 1168-75.
114. Konerding, M.A., et al., *Correlation of endoanal sonography with cross-sectional anatomy of the anal sphincter.* Gastrointest Endosc, 1999. **50**(6): p. 804-10.

115. Williams, A.B., et al., *Gender differences in the longitudinal pressure profile of the anal canal related to anatomical structure as demonstrated on three-dimensional anal endosonography.* Br J Surg, 2000. **87**(12): p. 1674-9.
116. Hill, J.R., et al., *Pressure profile of the rectum and anus of healthy persons.* Dis Colon Rectum, 1960. **3**: p. 203-9.
117. Schuster, M.M., et al., *Simultaneous Manometric Recording of Internal and External Anal Sphincteric Reflexes.* Bull Johns Hopkins Hosp, 1965. **116**: p. 79-88.
118. Lowry, A.C., et al., *Consensus statement of definitions for anorectal physiology and rectal cancer: report of the Tripartite Consensus Conference on Definitions for Anorectal Physiology and Rectal Cancer, Washington, D.C., May 1, 1999.* Dis Colon Rectum, 2001. **44**(7): p. 915-9.
119. Miller, R., et al., *Sensory discrimination and dynamic activity in the anorectum: evidence using a new ambulatory technique.* Br J Surg, 1988. **75**(10): p. 1003-7.
120. Felt-Bersma, R.J., E.C. Klinkenberg-Knol, and S.G. Meuwissen, *Anorectal function investigations in incontinent and continent patients. Differences and discriminatory value.* Dis Colon Rectum, 1990. **33**(6): p. 479-85; discussion 485-6.
121. McHugh, S.M. and N.E. Diamant, *Effect of age, gender, and parity on anal canal pressures. Contribution of impaired anal sphincter function to fecal incontinence.* Dig Dis Sci, 1987. **32**(7): p. 726-36.
122. Laurberg, S., M. Swash, and M.M. Henry, *Delayed external sphincter repair for obstetric tear.* Br J Surg, 1988. **75**(8): p. 786-8.
123. Matzel, K.E., et al., *Sacral spinal nerve stimulation for faecal incontinence: multicentre study.* Lancet, 2004. **363**(9417): p. 1270-6.
124. Chan, M.K. and J.J. Tjandra, *Sacral nerve stimulation for fecal incontinence: external anal sphincter defect vs. intact anal sphincter.* Dis Colon Rectum, 2008. **51**(7): p. 1015-24; discussion 1024-5.
125. Kamm, M.A., et al., *Sacral nerve stimulation for intractable constipation.* Gut. **59**(3): p. 333-40.
126. Tjandra, J.J., et al., *Injectable silicone biomaterial for fecal incontinence caused by internal anal sphincter dysfunction is effective.* Dis Colon Rectum, 2004. **47**(12): p. 2138-46.
127. Collinson, R., et al., *Laparoscopic ventral rectopexy for internal rectal prolapse: short-term functional results.* Colorectal Dis. **12**(2): p. 97-104.
128. Pescatori, M., M. Spyrou, and A. Pulvirenti d'Urso, *A prospective evaluation of occult disorders in obstructed defecation using the 'iceberg diagram'.* Colorectal Dis, 2006. **8**(9): p. 785-9.
129. Kirk, J.A., B.M. Ansell, and E.G. Bywaters, *The hypermobility syndrome. Musculoskeletal complaints associated with generalized joint hypermobility.* Ann Rheum Dis, 1967. **26**(5): p. 419-25.
130. Carter, C. and J. Wilkinson, *Persistent Joint Laxity and Congenital Dislocation of the Hip.* J Bone Joint Surg Br, 1964. **46**: p. 40-5.
131. Grahame, R., H.A. Bird, and A. Child, *The revised (Brighton 1998) criteria for the diagnosis of benign joint hypermobility syndrome (BJHS).* J Rheumatol, 2000. **27**(7): p. 1777-9.

132. Hall, M.G., et al., *The effect of the hypermobility syndrome on knee joint proprioception.* Br J Rheumatol, 1995. **34**(2): p. 121-5.
133. Beighton, P., L. Solomon, and C.L. Soskolne, *Articular mobility in an African population.* Ann Rheum Dis, 1973. **32**(5): p. 413-8.
134. Harris, H. and J. Joseph, *Variation in extension of the metacarpo-phalangeal and interphalangeal joint of the thumb.* J Bone Joint Surg Br, 1949. **31B**(4): p. 547-59, illust.
135. Al-Rawi, Z.S., A.J. Al-Aszawi, and T. Al-Chalabi, *Joint mobility among university students in Iraq.* Br J Rheumatol, 1985. **24**(4): p. 326-31.
136. Larsson, L.G., et al., *Hypermobility: prevalence and features in a Swedish population.* Br J Rheumatol, 1993. **32**(2): p. 116-9.
137. Jessee, E.F., D.S. Owen, Jr., and K.B. Sagar, *The benign hypermobile joint syndrome.* Arthritis Rheum, 1980. **23**(9): p. 1053-6.
138. Hakim, A. and R. Grahame, *Joint hypermobility.* Best Pract Res Clin Rheumatol, 2003. **17**(6): p. 989-1004.
139. Bird, H.A., *Joint hypermobility in children.* Rheumatology (Oxford), 2005. **44**(6): p. 703-4.
140. Calguneri, M., H.A. Bird, and V. Wright, *Changes in joint laxity occurring during pregnancy.* Ann Rheum Dis, 1982. **41**(2): p. 126-8.
141. McCormack, M., et al., *Joint laxity and the benign joint hypermobility syndrome in student and professional ballet dancers.* J Rheumatol, 2004. **31**(1): p. 173-8.
142. Larsson, L.G., J. Baum, and G.S. Mudholkar, *Hypermobility: features and differential incidence between the sexes.* Arthritis Rheum, 1987. **30**(12): p. 1426-30.
143. Grahame, R. and H. Bird, *British consultant rheumatologists' perceptions about the hypermobility syndrome: a national survey.* Rheumatology (Oxford), 2001. **40**(5): p. 559-62.
144. Malfait, F., et al., *The genetic basis of the joint hypermobility syndromes.* Rheumatology (Oxford), 2006. **45**(5): p. 502-7.
145. Hakim, A.J., et al., *The genetic epidemiology of joint hypermobility: a population study of female twins.* Arthritis Rheum, 2004. **50**(8): p. 2640-4.
146. Schalkwijk, J., et al., *A recessive form of the Ehlers-Danlos syndrome caused by tenascin-X deficiency.* N Engl J Med, 2001. **345**(16): p. 1167-75.
147. Zweers, M.C., et al., *Haploinsufficiency of TNXB is associated with hypermobility type of Ehlers-Danlos syndrome.* Am J Hum Genet, 2003. **73**(1): p. 214-7.
148. Hakim, A.J. and R. Grahame, *A simple questionnaire to detect hypermobility: an adjunct to the assessment of patients with diffuse musculoskeletal pain.* Int J Clin Pract, 2003. **57**(3): p. 163-6.
149. Martin-Santos, R., et al., *Association between joint hypermobility syndrome and panic disorder.* Am J Psychiatry, 1998. **155**(11): p. 1578-83.
150. Gazit, Y., et al., *Dysautonomia in the joint hypermobility syndrome.* Am J Med, 2003. **115**(1): p. 33-40.
151. Cotton, D.J. and K.D. Brandt, *Cardiovascular abnormalities in the Marfanoid hypermobility syndrome.* Arthritis Rheum, 1976. **19**(4): p. 763-8.

152. Pitcher, D. and R. Grahame, *Mitral valve prolapse and joint hypermobility: evidence for a systemic connective tissue abnormality?* Ann Rheum Dis, 1982. **41**(4): p. 352-4.
153. Handler, C.E., et al., *Mitral valve prolapse, aortic compliance, and skin collagen in joint hypermobility syndrome.* Br Heart J, 1985. **54**(5): p. 501-8.
154. Mishra, M.B., et al., *Extra-articular features of benign joint hypermobility syndrome.* Br J Rheumatol, 1996. **35**(9): p. 861-6.
155. Morgan, A.W., et al., *Asthma and airways collapse in two heritable disorders of connective tissue.* Ann Rheum Dis, 2007. **66**(10): p. 1369-73.
156. Beighton, P., *Obstetric aspects of the Ehlers-Danlos syndrome.* J Obstet Gynaecol Br Commonw, 1969. **76**(2): p. 97-101.
157. Arendt-Nielsen, L., et al., *Insufficient effect of local analgesics in Ehlers Danlos type III patients (connective tissue disorder).* Acta Anaesthesiol Scand, 1990. **34**(5): p. 358-61.
158. Hakim, A.J., et al., *Local anaesthetic failure in joint hypermobility syndrome.* J R Soc Med, 2005. **98**(2): p. 84-5.
159. Samuelsson, E.C., et al., *Signs of genital prolapse in a Swedish population of women 20 to 59 years of age and possible related factors.* Am J Obstet Gynecol, 1999. **180**(2 Pt 1): p. 299-305.
160. Bump, R.C., et al., *The standardization of terminology of female pelvic organ prolapse and pelvic floor dysfunction.* Am J Obstet Gynecol, 1996. **175**(1): p. 10-7.
161. Hendrix, S.L., et al., *Pelvic organ prolapse in the Women's Health Initiative: gravity and gravidity.* Am J Obstet Gynecol, 2002. **186**(6): p. 1160-6.
162. Schaffer, J.I., C.Y. Wai, and M.K. Boreham, *Etiology of pelvic organ prolapse.* Clin Obstet Gynecol, 2005. **48**(3): p. 639-47.
163. Nichols, D., *Vaginal Surgery*. 1978, Baltimore: Williams and Wilkins.
164. Carley, M.E. and J. Schaffer, *Urinary incontinence and pelvic organ prolapse in women with Marfan or Ehlers Danlos syndrome.* Am J Obstet Gynecol, 2000. **182**(5): p. 1021-3.
165. Makinen, J., et al., *Histological changes in the vaginal connective tissue of patients with and without uterine prolapse.* Arch Gynecol, 1986. **239**(1): p. 17-20.
166. Liapis, A., et al., *Changes of collagen type III in female patients with genuine stress incontinence and pelvic floor prolapse.* Eur J Obstet Gynecol Reprod Biol, 2001. **97**(1): p. 76-9.
167. Meyer, S., et al., *The effects of birth on urinary continence mechanisms and other pelvic-floor characteristics.* Obstet Gynecol, 1998. **92**(4 Pt 1): p. 613-8.
168. Wong, M.Y., et al., *Collagen content of nonsupport tissue in pelvic organ prolapse and stress urinary incontinence.* Am J Obstet Gynecol, 2003. **189**(6): p. 1597-9; discussion 1599-1600.
169. Soderberg, M.W., et al., *Young women with genital prolapse have a low collagen concentration.* Acta Obstet Gynecol Scand, 2004. **83**(12): p. 1193-8.
170. Moalli, P.A., et al., *Remodeling of vaginal connective tissue in patients with prolapse.* Obstet Gynecol, 2005. **106**(5 Pt 1): p. 953-63.

171. Goepel, C., *Differential elastin and tenascin immunolabeling in the uterosacral ligaments in postmenopausal women with and without pelvic organ prolapse.* Acta Histochem, 2008. **110**(3): p. 204-9.
172. ZS, A.L.-R. and Z.T. Al-Rawi, *Joint hypermobility in women with genital prolapse.* Lancet, 1982. **1**(8287): p. 1439-41.
173. Norton, P.A., et al., *Genitourinary prolapse and joint hypermobility in women.* Obstet Gynecol, 1995. **85**(2): p. 225-8.
174. Marshman, D., et al., *Rectal prolapse: relationship with joint mobility.* Aust N Z J Surg, 1987. **57**(11): p. 827-9.
175. Jha, S., A.S. Arunkalaivanan, and R.D. Situnayake, *Prevalence of incontinence in women with benign joint hypermobility syndrome.* Int Urogynecol J Pelvic Floor Dysfunct, 2007. **18**(1): p. 61-4.
176. Arunkalaivanan, A.S., et al., *Prevalence of urinary and faecal incontinence among female members of the Hypermobility Syndrome Association (HMSA).* J Obstet Gynaecol, 2009. **29**(2): p. 126-8.
177. Morren, G.L., et al., *Clinical measurement of pelvic floor movement: evaluation of a new device.* Dis Colon Rectum, 2004. **47**(5): p. 787-91; discussion 791-2.
178. Thompson, J.R., et al., *Incidence of occult rectal prolapse in patients with clinical rectoceles and defecatory dysfunction.* Am J Obstet Gynecol, 2002. **187**(6): p. 1494-9; discussion 1499-500.
179. Jarrett, M.E., et al., *Enterocoele is a marker of severe pelvic floor weakness.* Colorectal Dis. **12**(7 Online): p. e158-62.
180. D'Hoore, A., D. Vanbeckevoort, and F. Penninckx, *Clinical, physiological and radiological assessment of rectovaginal septum reinforcement with mesh for complex rectocele.* British Journal of Surgery, 2008. **95**(10): p. 1264-1272.
181. Altomare, D.F., et al., *Set-up and statistical validation of a new scoring system for obstructed defaecation syndrome.* Colorectal Dis, 2008. **10**(1): p. 84-8.
182. Chen, B.H., et al., *Collagen metabolism and turnover in women with stress urinary incontinence and pelvic prolapse.* Int Urogynecol J Pelvic Floor Dysfunct, 2002. **13**(2): p. 80-7; discussion 87.
183. Karam, J.A., et al., *Elastin expression and elastic fibre width in the anterior vaginal wall of postmenopausal women with and without prolapse.* BJU Int, 2007. **100**(2): p. 346-50.
184. Klutke, J., et al., *Decreased endopelvic fascia elastin content in uterine prolapse.* Acta Obstet Gynecol Scand, 2008. **87**(1): p. 111-5.
185. Yamamoto, K., et al., *Decrease in elastin gene expression and protein synthesis in fibroblasts derived from cardinal ligaments of patients with prolapsus uteri.* Cell Biol Int, 1997. **21**(9): p. 605-11.
186. Lin, S.Y., et al., *Changes in the extracellular matrix in the anterior vagina of women with or without prolapse.* Int Urogynecol J Pelvic Floor Dysfunct, 2007. **18**(1): p. 43-8.
187. Barbiero, E.C., et al., *Analysis of type I collagen in the parametrium of women with and without uterine prolapse, according to hormonal status.* Int Urogynecol J Pelvic Floor Dysfunct, 2003. **14**(5): p. 331-4; discussion 334.
188. Williams, G., *The late phases of wound healing: histological and ultrastructural studies of collagen and elastic-tissue formation.* J Pathol, 1970. **102**(2): p. 61-8.