

Establishing the safety of the lateral femoral cutaneous nerve when using the Bridging Infix for anterior pelvic fixation

Jerolize van Schalkwyk,^{1*}  Natalie Keough,^{1,2,3} Sven Strydom,⁴ Christian H Snyckers,⁵ Andries Masenge,⁶ Nkhensani Mogale¹

¹ Department of Anatomy, University of Pretoria, Pretoria, South Africa

² Department of Anatomy and Cellular Biology, Khalifa University, Abu Dhabi, United Arab Emirates

³ Clinical Anatomy and Imaging, Warwick Medical School, University of Warwick, Coventry, United Kingdom

⁴ Department of Orthopaedics, University of Pretoria, Kalafong Tertiary Hospital, Pretoria, South Africa

⁵ Orthopaedic Surgery, Private Practice, Eugene Marais Hospital, South Africa

⁶ Department of Statistics, University of Pretoria, Pretoria, South Africa

*Corresponding author: jerolizevs@outlook.com

Citation: Van Schalkwyk J, Keough N, Strydom S, Snyckers CH, Masenge A, Mogale N. Establishing the safety of the lateral femoral cutaneous nerve when using the Bridging Infix for anterior pelvic fixation. *SA Orthop J*. 2023;22(4):198-203. <http://dx.doi.org/10.17159/2309-8309/2023/v22n4a5>

Editor: Dr Luan Nieuwoudt, University of KwaZulu-Natal, Durban, South Africa

Received: April 2023

Accepted: June 2023

Published: November 2023

Copyright: © 2023 Van Schalkwyk J. This is an open-access article distributed under the terms of the Creative Commons Attribution Licence, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

Funding: This work is based on the research supported by the National Research Foundation (NRF) of South Africa (grant number: 120410). The funding source had no involvement in the study design, data collection, analysis and interpretation of the data; in the writing of the report; or in the decision to submit the article for publication.

Conflict of interest: The authors declare they have no conflicts of interest that are directly or indirectly related to the research.

Abstract

Background

Established subcutaneous internal fixation techniques have shown a better quality of life with reduced pain. However, complications still arise, with the most significant being injury of the lateral femoral cutaneous nerve (LFCN). A novel minimally invasive modified technique, the Bridging Infix, has been proposed; however, the safety of the LFCN during the procedure is currently unknown. The aim of the study, therefore, was to determine the relationship between the Bridging Infix and the LFCN.

Method

Fifty formalin-fixed cadaveric specimens and two fresh frozen cadaver specimens were utilised in the study. The Bridging Infix was inserted as per the technique guide. Superficial dissection of the surgical site was subsequently conducted. Bilateral measurements of the distance between the LFCN and the implant as well as palpable bony landmarks were taken to determine safe zones for implant placement.

Results

Overall the LFCN was identified coursing deep to the inguinal ligament. The minimum distance from the LFCN to the most proximal cortical screw was 18.00 mm. The mean distance from the most proximal screw to the LFCN was 37.97 ± 12.20 mm.

Conclusion

The LFCN was not injured or impinged by the Bridging Infix in any of the cadaver specimens used in this study. Thus, the surgical procedure can be considered safe if layer by layer dissection is employed and the screws are directly inserted on the iliac crest, with no pressure being applied within three finger breadths medial to the anterior superior iliac spine.

Level of evidence: Level 3

Keywords: Bridging Infix, lateral femoral cutaneous nerve, anterior pelvic fixation, anterior superior iliac spine, pubic tubercle

Introduction

Pelvic ring injuries account for approximately 8% of injuries in trauma cases,^{1,3} and 0.3–6% of all fractures.^{4,6} Although the prevalence of pelvic ring injuries is lower in comparison to other fractures, these injuries are known to have both high morbidity and mortality rates.^{1,2} Surgical interventions for anterior pelvic fixation

have been well established. Traditional subcutaneous internal fixation techniques have shown reduced wound complications, better quality of life and reduced pain. However, these techniques still have specific indications, contraindications and complications. The most significant known complication for these techniques is injury of the lateral femoral cutaneous nerve (LFCN).

The LFCN originates from the anterior rami of roots L2–L3 of the lumbar plexus and supplies the skin of the lateral and anterior thigh to the level of the knee.⁷⁻⁹ It exits the lateral border of the psoas major muscle and passes obliquely inferior across the iliacus muscle.^{8,9} The LFCN courses 20–30 mm inferomedial towards the anterior superior iliac spine (ASIS) where it passes deep to the inguinal ligament.^{8,10} It pierces through the fascia lata inferior to the inguinal ligament, entering the thigh.⁹

The course of the LFCN has, however, been reported to vary in at least 25% of patients,^{9,11} and up to three sub-branches have been previously described.¹² Variations in the origin of the LFCN have also been described, such as contributions from both L1 and L4 nerve roots^{13,14} or a single origin from only L2.¹⁴ Reinpold et al. reported that the LFCN entered the abdomen 5–6 mm laterally (5%), 3–56 mm medially (95%), 10 mm cranially (10%), and 14 mm caudally (90%) to the ASIS.¹² However, other publications have reported the LFCN coursing superolateral to the ASIS in 2.9–4% of cases.^{15,16}

Due to its variable course, the LFCN is at a higher risk for damage especially in anterior pelvic surgery.^{17,18} It can be injured and/or compressed along its entire course, but most injuries occur as the nerve exits the pelvis.¹⁷ LFCN injury often presents as complex meralgia paresthetica, which manifests as a loss of sensation, burning, pain or itching over the area that the LFCN supplies.¹⁷⁻²⁰

Strydom et al. proposed a modified technique using an internal bridge plate and rod technique.²¹ This technique combines the benefits of open reduction internal fixation (ORIF) with external fixation methods, with the aim of reducing known complications. It is a modification of both the pelvic bridge and INFIX described by Hiesterman et al.²² and Vaidya et al.,²³ respectively. As the Bridging Infix follows the same course as the pelvic bridge, it is suspected that the incidence of LFCN injury would be similar to that of the pelvic bridge. Since the safety of the LFCN in this novel technique is unknown, this study aims to determine the relationship between the Bridging Infix and the LFCN as well as a safe zone for implantation.

Methods

The study sample consisted of 50 (n = 50) formalin-fixed cadavers and two (n = 2) fresh frozen specimens. The samples were obtained and handled in accordance with the National Health Act no. 61 of 2003 (ethical clearance: 182/2021). Cadavers with evidence of previous abdominopelvic surgeries, pathology, or damage in the abdominopelvic region were excluded. The

proximity of surrounding anatomical structures to the Bridging Infix was investigated through superficial dissections of the anterior abdominopelvic wall.

Prior to implanting the Bridging Infix, each plate-rod from the Occipito-Cervical Fusion System manufactured by DePuy Synthes (Massachusetts, USA) was externally contoured, by an orthopaedic surgeon, according to the curvature of each cadaver's pelvis. Direct visualisation was used to determine if the construct was adequately contoured as no imaging was available.

Both samples followed similar dissection procedures. With the cadaver in a supine position, the skin and subcutaneous tissue was reflected laterally and removed. A vertical incision was made \pm 10 mm inferior to the ASIS, into the tensor fascia lata to expose the LFCN as it emerged from the inguinal ligament. Parts of the tensor fascia lata were removed to fully expose the LFCN course. In cases where the nerve emerged as more than one branch, the most lateral branch was measured.

In the two different samples, the Bridging Infix implantation procedures differed. Due to the rigidity of the formalin-fixed cadavers, it was deemed unfeasible to easily create a subcutaneous tunnel as required. Therefore, the implantation procedure was a modified version published by Strydom et al.²¹ In the fresh frozen samples, the surgical technique was strictly adhered to as the tissue elasticity was identical to a live patient undergoing the surgical procedure.

In the fresh frozen specimens, the surgical implantation procedure was followed before dissection. Three surgical incisions were made: two incisions for the lateral windows, extending from the ASIS, 40 mm along the iliac crest, and a horizontal incision for the medial window \pm 10 mm superior to the pubic symphysis. A subcutaneous tunnel was created between the medial and lateral windows. Kocher forceps were used to pull the plate-rod through the tunnel.

In both samples, the external oblique fascia was lifted off the iliac crest and the periosteum was cleaned off the iliac crest to create a bare area for fixation. The plate was placed on the bare area and secured with three cortical screws into the ala. The plate-rods were connected to a connecting rod with rod-to-rod clamps (*Figure 1*).

Following the dissection and implantation procedures, the following distances were measured using a sliding mechanical calliper of 0.1 mm accuracy (*Figure 2*). First, the distance from the midpoint of the most medial screw head to the LFCN emergence at the inguinal ligament was measured. Next, the distance between the ASIS and the LFCN emergence at the inguinal ligament was determined. Thirdly, a measurement was taken from the midpoint

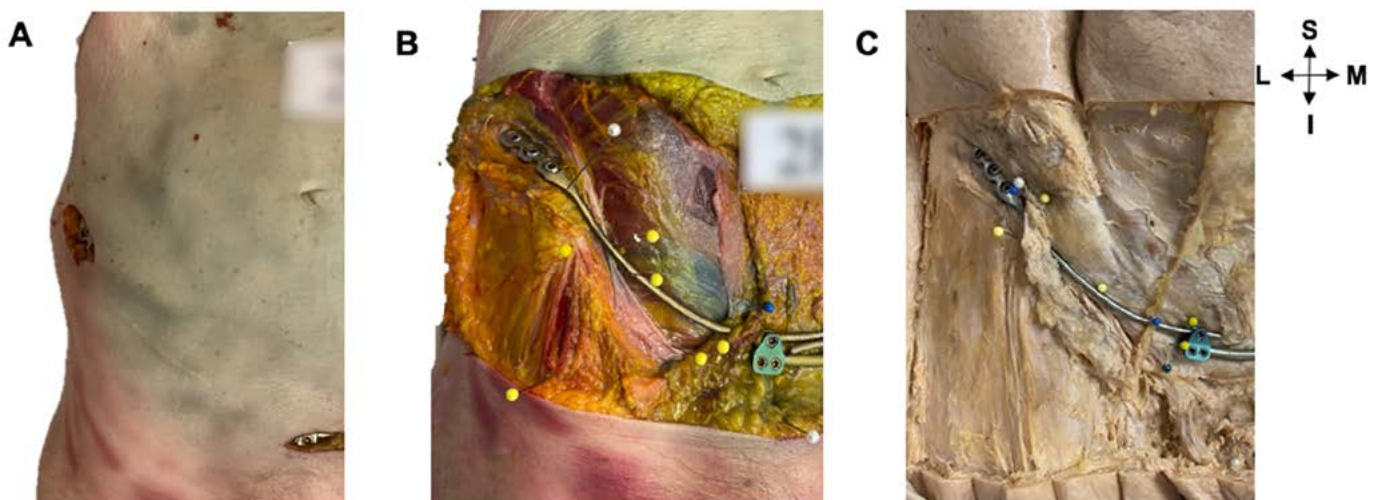


Figure 1. Bridging Infix implanted between the iliac crests and pubic symphysis on the right

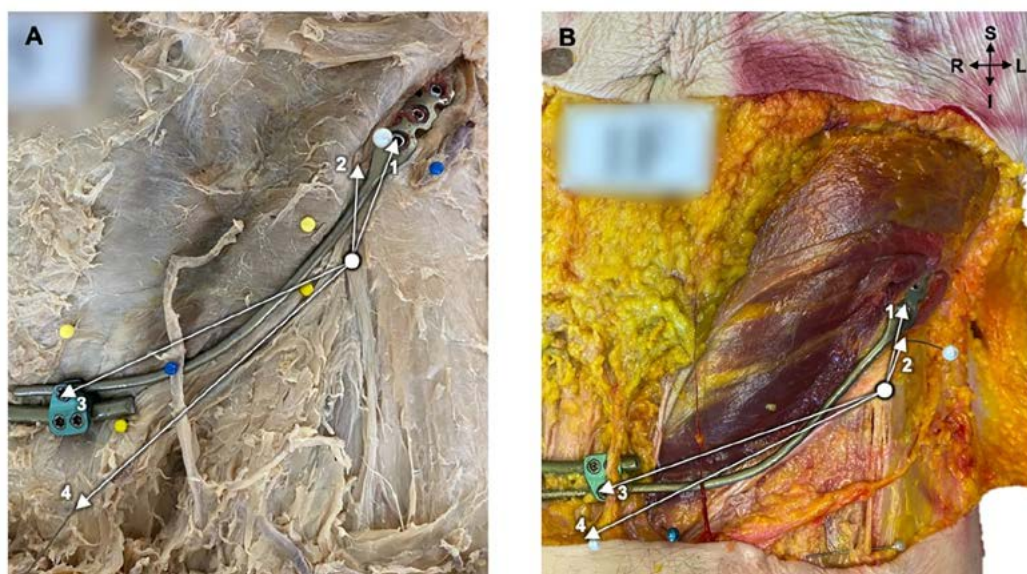


Figure 2. Cadaver images indicating the LFCN measurements of the right proximal thigh

of the implant rod-to-rod connector single screw to the LFCN as it emerges from the inguinal ligament. Finally, the distance originating from the most prominent point of pubic tubercle to the LFCN emergence was measured. In addition, the distance between the ASIS and pubic tubercle was measured. All measurements were taken bilaterally and recorded for data analysis.

In the fresh frozen samples (n = 2), additional measurements were recorded to determine if flexion of the hips (> 45°) influenced the measurements taken. In order to accurately evaluate the impact flexion had on the measured distances, only one hip was flexed at a time. The distance from the 40 mm cortical screw head and the distance from the midpoint of the implant rod-to-rod connector single screw to the emergence of the LFCN from the inguinal ligament was re-measured. These measurements were compared to the same measurements taken with the hips extended.

Statistical analysis was conducted using SPSS IBM Statistics version 27. The data analysis included descriptive statistics and statistical tests. The samples were tested for normality, followed by a paired t-test or Wilcoxon signed rank test to test for differences between the left- and right-side measurements. To test for differences between the sexes, a t-test was conducted for normally

distributed data or a Mann-Whitney U test for skewed data. For testing difference in the BMI groups, a Kruskal-Wallis test was performed. Furthermore, Mann-Whitney U tests were conducted for comparisons between the flexed and straight hips of the fresh frozen sample. A p-value ≤ 0.05 was considered statistically significant.

Results

The LFCN was identified in all specimens on both the left and right sides. All measurements were determined to be normally distributed using a paired t-test. In order to determine if a difference exists between equivalent measurements taken on the left and right side of the cadavers, a paired t-test was performed in the formalin-fixed samples only. A significant difference (p < 0.05) was only found between the measurements taken on the left and right side for the distance between the midpoint of the single rod-to-rod connecting screw and the LFCN emergence at the inguinal ligament. All the other measurements were determined to be analogous and therefore the measurements were pooled for further testing. The results are indicated in *Table 1*.

Table 1: Test for difference between lateral femoral cutaneous nerve on the left and right

Sample	Measurement origin	n	Side	Mean	SD	99% CI		p-value
						Lower	Upper	
Formalin-fixed	40 mm cortical screw	100	-	37.97	12.20	34.76	41.17	0.388
	ASIS	100	-	28.77	11.88	25.65	31.89	0.411
	Rod-to-rod connector screw	50	L	105.57	15.71	99.61	111.52	0.000
		50	R	96.04	11.79	91.57	100.50	
	PT	100	-	115.97	14.73	112.10	119.84	0.222
Fresh frozen	40 mm cortical screw	2	L	28.74	2.96	20.09	37.38	-
		2	R	28.98	1.90	23.43	34.54	-
	ASIS	2	L	23.10	7.67	-321.92	368.12	-
		2	R	18.96	1.22	-35.78	73.70	-
	Rod-to-rod connector screw	2	L	94.05	11.08	61.68	126.41	-
		2	R	92.73	9.14	66.05	119.41	-
	PT	2	L	106.38	15.05	-570.93	783.69	-
		2	R	110.00	14.14	-526.57	746.57	-

n: sample size; SD: standard deviation; CI: confidence interval; ASIS: anterior superior iliac spine; PT: pubic tubercle; L: left; R: right (bold indicates statistically significant values p < 0.05)

The minimum distance in the formalin-fixed samples from the midpoint of the 40 mm cortical screw head to the LFCN was 18.00 mm, while being 26.06 mm in the fresh frozen samples. The minimum distance from the LFCN to the single rod-to-rod connecting screw was 67.28 mm on the left and 74.07 mm on the right for the formalin-fixed cadavers, while 84.07 mm was the minimum distance in the fresh frozen samples. The average distance between the ASIS and LFCN was 28.77 mm for the formalin-fixed sample, while the minimum distance was 17.68 mm in the fresh frozen samples. The measurements in the fresh specimens differed widely, but no inference could be made due to the small sample and should just be noted.

An independent sample t-test was performed to determine if sex had an influence on the measurements taken in the formalin-fixed cadaver sample. A significant difference between the sexes was only determined for the measurements originating from the implant rod-to-rod connector single screw to LFCN emergence on the left ($p = 0.012$) and the pubic tubercle to the LFCN emergence pooled ($p = 0.002$). In both cases, males were found to have larger values in comparison to females and can be explained by the sexual dimorphic differences between males and females.

The samples were divided into the three BMI categories: underweight (BMI < 18.5 kg/m²; n = 19), healthy (18.5 kg/m² ≤ BMI < 25 kg/m²; n = 17) and overweight/obese (BMI ≥ 25 kg/m²; n = 8). BMI values were unavailable for six of the cadaver specimens which were therefore excluded from this statistical analysis. A Kruskal-Wallis test determined that there was a significant difference for the distance from the rod-to-rod connecting single screw to the LFCN emergence on the left side only and BMI ($p = 0.005$), with overweight cadavers having greater measurements. The pooled distance between the pubic tubercle and LFCN was also significantly influenced by BMI, with individuals with BMI values greater than 25 kg/m² having larger measurements ($p = 0.009$).

In the fresh frozen samples, selected measurements were taken with the cadavers' hips in both a straight and flexed position. A Mann-Whitney U test was conducted to determine if flexion > 45° would influence the measurements taken, but no significant difference was found. Although the sample is small, it is possible to assume that flexion does not seem to influence the measurements taken. However, observations noted during the measurement process indicate that the LFCN was seen having slightly moved from the straight position to the flexed position.

Interclass correlation coefficients (ICC) were determined to ensure the reliability of results. ICCs were determined for each measurement. It was found that all ICCs were greater than 0.9, with a minimum of 0.914 and a maximum of 0.999. One distance, from the 40 mm cortical screw head to the LFCN on the right, was an exception with an ICC value of 0.204. Therefore, an acceptable intra- and interobserver reliability was concluded.

Discussion

The current study demonstrated that the use of the Bridging Infix for anterior pelvic fixation did not pose a significant risk to the LFCN. The LFCN is currently the most prevalent structure mentioned in literature relating to anterior pelvic fixation,^{2,5,21,22,24-26} and numerous studies have looked at its relationship to the ASIS.^{10,16,18,19,27-34} Additional and more pertinent distances were needed in order to establish the safety of the Bridging Infix technique, as structures in close relation to the ASIS, iliac crest and pubic tubercle would potentially be at risk during dissection and implant placement.

The cause of meralgia paresthetica can be either impingement or iatrogenic injury to the LFCN,^{20,33} with both conservative and surgical treatment being described with varying success rates.³¹ This highlights the importance of knowledge of the LFCN anatomy and its variations for surgeons performing anterior pelvic surgical procedures.

The mean distance from the LFCN to the medial screw was 37.96 ± 12.20 mm (range: 18.00–68.68 mm). The pedicle screws of the INFIX may cause potential nerve injury as it was reported that there was no safety margin in 90.9% of cadavers.²⁵ This is the first anatomical study of the Bridging Infix, thus measurements can only be compared against other similar techniques.

In all our samples the LFCN was observed emerging deep to the inguinal ligament^{10,34} and medial to the ASIS,^{29,31,34} which is comparable to existing literature. A recent meta-analysis by Tomaszewski et al. found the LFCN crossing over the ASIS in only 1.9% of the cases or through the ASIS in 2.4%.²⁰ Only in these circumstances would the LFCN be at risk with the Bridging Infix technique.

The ASIS is an easily palpable surgical landmark to determine the position of the LFCN.³⁴ A general guideline to estimate the LFCN course is two finger breadths medial to the ASIS.³³ We found that 30% of the measurements lay within a range of 30–40 mm medial to the ASIS. Since finger breadths vary, a 30 mm distance

Table II: Measurements for anterior superior iliac spine – lateral femoral cutaneous nerve emergence compared between studies

Study	Left			Right			Total		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
Dibenedetto et al. (1996) ²⁷							114	17	12
Sürücü et al. (1997) ²⁸	22			22			44	15.2	8.4
Hospodar et al. (1999) ²⁹							68	20.4	10.7
Grothaus et al. (2005) ¹⁹	14			15			29	36	20
Mischkowski et al. (2006) ¹⁶							34	14.6	
Bjurlin et al. (2007) ³⁰							22	26	19
Doklamyai et al. (2008) ¹⁰							43	20	
Ropars et al. (2009) ³¹							34	21.1	
Bodner et al. (2009) ³²	8	28	12	7	29	14			
Ray et al. (2010) ¹⁸	29	21.1	6.3	18	14.9	7.8	47	18.7	4.8
Majkrzak et al. (2010) ³³							14		15
Üzel et al. (2011) ³⁴	20	30.9	23.2	22	27.1	17.3	42	29.5	20.1
Current study (2022)	50	29.59	12.98	50	27.95	10.74	100	28.77	11.88

n: sample size; SD: standard deviation (bold indicates measurements ± 10 mm from current study)

is recommended by some authors.²⁰ We propose approximately 40 mm or three finger breadths medial to the ASIS may be a better approximation, taking the current study's measurement proportions into consideration.

Our findings regarding the distance between the ASIS and LFCN's emergence at the inguinal ligament are comparable to previous publications (*Table II*).^{30,32,34} We found the mean distance between the ASIS and LFCN was 28.77 ± 11.88 mm, while other studies reported smaller distances (*Table II*). The differences in measurements may be attributed to the fact that not all studies directly defined the exact position on the ASIS from where their measurements were taken.

Previous publications concluded that a danger zone for LFCN injury exists extending along the lateral border of the sartorius muscle and along the inguinal ligament for the common trunk of the LFCN, reaching as far as 73 mm.^{19,31} Our data is comparable with a maximum value of 60.89 mm.

Tomaszewski et al.²⁰ reported the mean distance from the ASIS to the LFCN as 19.0 mm and further analysis revealed that the North American and European groups had similar mean distances of 23.2 mm, while South Americans had a shorter distance of 9.9 mm. Our sample had the largest average ASIS–LFCN distance of 28.77 mm. Various differences, including geographical, BMI or population specificity, may result in measurement differences of the LFCN–ASIS. To our knowledge, no published studies have been conducted on the South African population regarding the LFCN location.

We found the average distance from ASIS to PT was 135.35 ± 12.69 mm, which is similar to previous studies.^{33,34} Bjurlin et al. related the distance from the ASIS to the LFCN emergence at the inguinal ligament as a percentage of the distance between the ASIS and PT as $19 \pm 14\%$.³⁰ Similarly we found the LFCN–ASIS distance was $21.24 \pm 8.57\%$ of the ASIS–PT distance. Üzel et al. also calculated the ratio for LFCN–ASIS/ASIS–PT to assist surgeons with patients of different body types and found the ratio to be 0.22 ± 0.16 (0.24 ± 0.20 for the left and 0.20 ± 0.12 for the right) which corresponds to a ratio of 0.21 ± 0.09 in our study.³⁴ Thus, the LFCN can be found medial to the ASIS approximately one-fifth of the distance between the ASIS and PT along the inguinal ligament.

Doklamiy et al. measured the distance between the LFCN and PT and reported the distance as approximately 110 mm in males and 100 mm in females (range: 83–127 mm).¹⁰ This is equivalent to the 115.97 mm average documented in our study.

In the fresh frozen samples, selected measurements were taken with the cadavers' hips in both extension and flexion. When comparing hip flexion ($\pm 70^\circ$) and extension positions, flexion did not significantly influence the measurements taken between the Bridging Infix and surrounding structures. However, observations noted during the measurement process indicate that the LFCN was seen having slightly moved from the extended to the flexed position. Although the sample is small, it is possible to assume that flexion does not seem to significantly influence the measurements taken. In contrast, Osterhoff et al. investigated 90° hip flexion using the INFIX and indicated that the LFCN was compressed in up to 80% of the samples.²⁴ The INFIX is, however, fastened to the anterior inferior iliac spine and does not align with the inguinal ligament.²⁶ It can be hypothesised that the Bridging Infix does not compress the LFCN due to its alignment with the inguinal ligament.

Limitations of the study include the small sample size of the fresh frozen samples. Majkrzak et al. reported that fresh and formalin-fixed specimen data sets were statistically equivalent in their study.³³ This analysis could not be conducted in the present study due to the sample size difference. Significant variations in the measurements originating from the rod-to-rod connector were seen as this is not a stable point on the implant.

Complications can be avoided by strict surgical technique and advanced knowledge of the known variation prevalence. Only if the surgeon employs layer-by-layer dissection down to the level of the periosteum of the iliac crest, can a possible LFCN variation be appreciated and preserved. The Bridging Infix technique already employs this and therefore it is believed to reduce the risk of damage due to anatomical variations.

Conclusion

Variations of the LFCN are of importance, as various surgical approaches relating to anterior pelvis fixation would put the LFCN at risk. The LFCN emerges approximately 28.77 mm medial to the most prominent point of the ASIS along the inguinal ligament. This is equivalent to approximately one-fifth the distance between the ASIS and PT. Relating specifically to the Bridging Infix procedure, the LFCN can be considered to be a safe distance from the cortical screws when they are directly inserted into the iliac crest.

Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Prior to commencement of the study, ethical approval was obtained from the following ethical review board: University of Pretoria's Health Science Research Ethics Committee (ethical clearance: 182/2021).

Informed written consent was not required as cadaveric materials were used in the study.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

JvS: study design, literature review, data collection, data capture, data analysis, manuscript preparation,

NK: study design, manuscript review

SS: procedure conceptualisation, procedure execution, manuscript review

CHS: procedure conceptualisation, procedure execution, manuscript review

AM: statistical analysis, manuscript review

NM: study design, manuscript review

ORCID

Van Schalkwyk J  <https://orcid.org/0000-0002-9200-2614>

Keough N  <https://orcid.org/0000-0001-8249-8727>

Strydom S  <https://orcid.org/0000-0002-6288-4388>

Snyckers CH  <https://orcid.org/0000-0002-6297-894X>

Masenge A  <https://orcid.org/0000-0001-8372-2356>

Mogale N  <https://orcid.org/0000-0002-4499-6626>

References

1. Mason WTM, Khan SN, James CL, et al. Complications of temporary and definitive external fixation of pelvic ring injuries. *Injury*. 2005;36:599-604. <https://doi.org/10.1016/j.injury.2004.11.016>
2. Moazzam C, Heddings AA, Moodie P, et al. Anterior pelvic subcutaneous internal fixator application: an anatomic study. *J Orthop Trauma*. 2012;26(5):263-68. <https://doi.org/10.1097/BOT.0b013e31823e6b82>
3. Hung C, Wu J, Li Y, et al. Minimally invasive treatment for anterior pelvic ring injuries with modified pedicle screw-rod fixation: a retrospective study. *J Orthop Surg Res*. 2018;13(1):1-8. <https://doi.org/10.1186/s13018-018-0945-4>
4. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. *Injury*. 2006;37(8):691-97. <https://doi.org/10.1016/j.injury.2006.04.130>
5. Cole PA, Gauger EM, Anavian J, et al. Anterior pelvic external fixator versus subcutaneous internal fixator in the treatment of anterior ring pelvic fractures. *J Orthop Trauma*. 2012;26(5):269-77. <https://doi.org/10.1097/BOT.0b013e3182410577>
6. Küper MA, Trulsson A, Stuby FM, et al. Pelvic ring fractures in the elderly. *EFORT Open Rev*. 2019;4:313-20. <https://doi.org/10.1302/2058-5241.4.180062>
7. Moore KL, Dalley AF, Aguir AMR. Moore Clinically orientated anatomy. 7th ed. Philadelphia: Lippincott Williams & Wilkins, 2014.

8. Drake RL, Vogl AW, Mitchell AWM. *Gray's anatomy for students*. 3rd ed. Philadelphia: Churchill Livingstone Elsevier, 2015: 398-401.
9. Tubbs RS, Loukas M, Hanna AS. *Surgical anatomy of the lumbar plexus*. Thieme Medical Publishers, Incorporated, New York. 2018. Available from: ProQuest Ebook Central. [17 February 2021].
10. Doklanyai P, Agthong S, Chentanez V, et al. Anatomy of the lateral femoral cutaneous nerve related to inguinal ligament, adjacent bony landmarks and femoral artery. *Clin Anat*. 2008;21:769-74. <https://doi.org/10.1002/ca.20716>
11. De Ridder VA, de Lange S, Popta JV. Anatomical variations of the lateral femoral cutaneous nerve and the consequences for surgery. *J Orthop Trauma*. 1999;13(3):207-11. <https://doi.org/10.1097/00005131-199903000-00009>
12. Reinhold W, Schroeder M, Berger C, et al. Retroperitoneal anatomy of the iliohypogastric, ilioinguinal, genitofemoral and lateral femoral cutaneous nerve: consequences for prevention and treatment of chronic inguinodynia. *Hernia*. 2015;19(4):539-48. <https://doi.org/10.1007/s10029-015-1396-z>
13. Apaydin N. Variations of the lumbar and sacral plexuses and their branches. In: Tubbs RS, Rizk E, Shoja MM, Loukas M, Barbaro N, Spinner RJ, eds. *Nerves and Nerve Injuries*. Vol 1. San Diego: Elsevier. 2015:614-17.
14. Anloague PA, Huijbregts P. Anatomical variations of the lumbar plexus: a descriptive anatomy study with proposed clinical implications. *J Manual Manip Ther*. 2009;17(4):e107-e114. <https://doi.org/10.1179/106698109791352201>
15. Aszmann OC, Dellon ES, Dellon AL. Anatomical course of the lateral femoral cutaneous nerve and its susceptibility to compression and injury. *Plast Reconstr Surg*. 1997;100:600-604. <https://doi.org/10.1097/00006534-199709000-00008>
16. Mischkowski RA, Selbach I, Neugebauer J, et al. Lateral femoral cutaneous nerve and iliac crest bone grafts - anatomical and clinical considerations. *Int J Oral Maxillofac Surg*. 2006;35:366-72. <https://doi.org/10.1016/j.ijom.2005.08.010>
17. Grossman MG, Ducey SA, Nadler SS, et al. Meralgia paresthetica: diagnosis and treatment. *J Am Acad Orthop Surg*. 2001;9:336-44. <https://doi.org/10.5435/00124635-200109000-00007>
18. Ray B, D'Souza AS, Kumar B, et al. Variations in the course and microanatomical study of the lateral femoral cutaneous nerve and its clinical importance. *Clin Anat*. 2010;23:978-84. <https://doi.org/10.1002/ca.21043>
19. Grothaus MC, Holt M, Mekhail AO, et al. Lateral femoral cutaneous nerve: an anatomic study. *Clin Orthop Relat Res*. 2005;437:164-68. <https://doi.org/10.1097/01.blo.0000164526.08610.97>
20. Tomaszewski KA, Popieluszko P, Henry BM, et al. The surgical anatomy of the lateral femoral cutaneous nerve in the inguinal region: a meta-analysis. *Hernia*. 2016;20:649-57. <https://doi.org/10.1007/s10029-016-1493-7>
21. Strydom S, Snyckers CH. Minimally invasive subcutaneous anterior fixation of pelvic fractures in the elderly: case report and literature review. *S Afr Orthop J*. 2021;20(4):240-45. <https://doi.org/10.17159/2309-8309/2021/v20n4a8>
22. Hiesterman T, Hill B, Cole P. Surgical technique: a percutaneous method of subcutaneous fixation for the anterior pelvic ring: the pelvic bridge. *Clin Orthop Relat Res*. 2012;470(8):2116-23. <https://doi.org/10.1007/s11999-012-2341-4>
23. Vaidya R, Colen R, Vigdorichik J, et al. Treatment of unstable pelvic ring injuries with an internal anterior fixator and posterior fixation: initial clinical series. *J Orthop Trauma*. 2012;26(1):1-8. <https://doi.org/10.1097/BOT.0b013e318233b8a7>
24. Osterhoff G, Aichner EV, Scherer J, et al. Anterior subcutaneous internal fixation of the pelvis – what rod-to-bone distance is anatomically optimal. *Injury*. 2017;48:2162-68. <https://doi.org/10.1016/j.injury.2017.08.047>
25. Reichel LM, MacCormick LM, Dugarte AJ, et al. Minimally invasive anterior pelvic internal fixation: an anatomic study comparing Pelvic Bridge to INFIX. *Injury*. 2018;49:309-14. <https://doi.org/10.1016/j.injury.2017.12.009>
26. Yin Y, Luo J, Zhang R, et al. Anterior subcutaneous internal fixator (INFIX) versus plate fixation for pelvic anterior ring fracture. *Sci Rep*. 2019;9(1):2578-78. <https://doi.org/10.1038/s41598-019-39068-7>
27. Dibenedetto LM, Lei Q, Gilroy AM, et al. Variations in the inferior pelvic pathway of the lateral femoral cutaneous nerve: implications for laparoscopic hernia repair. *Clin Anat*. 1996;9:232-36. [https://doi.org/10.1002/\(SICI\)1098-2353\(1996\)9:4<232::AID-CA3>3.0.CO;2-G](https://doi.org/10.1002/(SICI)1098-2353(1996)9:4<232::AID-CA3>3.0.CO;2-G)
28. Sürücü HS, Tanyeli E, Sargon MF, et al. An anatomic study of the lateral femoral cutaneous nerve. *Surg Radiol Anat*. 1997;19:307-10. <https://doi.org/10.1007/BF01637599>
29. Hospodar PP, Ashman ES, Traub JA. Anatomic study of the lateral femoral cutaneous nerve with respect to the ilioinguinal surgical dissection. *J Orthop Trauma*. 1999;13(1):17-19. <https://doi.org/10.1097/00005131-199901000-00005>
30. Bjurlin MA, Davis KE, Allin EF, et al. Anatomic variations in the lateral femoral cutaneous nerve with respect to pediatric hip surgery. *Am J Orthop*. 2007;36(3):143-46.
31. Ropars M, Morandi X, Hutten D, et al. Anatomical study of the lateral femoral cutaneous nerve with special reference to minimally invasive anterior approach for total hip replacement. *Surg Radiol Anat*. 2009;31:199-204. <https://doi.org/10.1007/s00276-008-0433-3>
32. Bodner G, Bernathova M, Galiano K, et al. Ultrasound of the lateral femoral cutaneous nerve. *Reg Anesth Pain Med*. 2009;34:265-68. <https://doi.org/10.1097/AAP.0b013e31819a4fc6>
33. Majkrzak A, Johnston J, Kacey D, et al. Variability of the lateral femoral cutaneous nerve: an anatomic basis for planning safe surgical approaches. *Clin Anat*. 2010;23:304-11. <https://doi.org/10.1002/ca.20943>
34. Üzel M, Akkin SM, Tanyeli E, et al. Relationships of the lateral femoral cutaneous nerve to bony landmarks. *Clin Orthop Relat Res*. 2011;469:2605-11. <https://doi.org/10.1007/s11999-011-1858-2>