Turun yliopisto
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BARIATRIC AND POST-BARIATRIC SURGERY

From Metabolic Surgery to Plastic Surgery Indications

Salvatore Giordano

TURUN YLIOPISTON JULKAISUJA – ANNALES UNIVERSITATIS TURKUENSIS
Sarja - ser. D osa - tom. 1153 | Medica - Odontologica | Turku 2014

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The originality of this thesis has been checked in accordance with the University of Turku quality assurance system using the Turnitin OriginalityCheck service.

ISBN 978-951-29-5983-9 (PRINT)
ISBN 978-951-29-5984-6 (PDF)
ISSN 0355-9483
Painosalama Oy - Turku, Finland 2014

"It's only when we become aware or are reminded that our time is limited that we can channel our energy into truly living"

Ludovico Einaudi

To my parents

ABSTRACT

Salvatore Giordano

Bariatric and Post-Bariatric Surgery: from Metabolic Surgery to Plastic Surgery Indications

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Annales Universitatis Turkuensis 2014
Turku 2014

Background: Controversy exists concerning indications and outcomes of major bariatric surgery procedures. Massive weight loss after bariatric surgery leads to excess skin with functional and aesthetic impairments. The aim of this study was to investigate the major bariatric surgery procedures and their outcomes in two specific subgroups of morbidly obese patients, ≥55-year-olds and the superobese. Further aims were to evaluate whether the preoperative weight loss correlates with laparoscopic gastric bypass complications. The prevalence and impact of excess skin and the desire for body contouring after bariatric surgery were also studied.

Patients and Methods: Data from patients who underwent Laparoscopic Adjustable Gastric Banding (LAGB) and Laparoscopic Roux-en-Y Gastric Bypass (LRYGB) at Vaasa Central Hospital were collected and postoperative outcomes were evaluated according to the BMI, age and preoperative weight loss. Patients who had undergone bariatric surgery procedures were asked to complete a questionnaire to estimate any impairment due to redundant skin and to analyse each patient's desire for body contouring by area.

Results: No significant difference was found in operative time, hospital stay, or overall early postoperative morbidity between LAGB and LRYGB. Mean excess weight loss percents (EWL%) at 6 and 12 months after LRYGB were significantly higher. A significant difference was found in operative time favouring patients <55 years. Intraoperative complications were significantly more frequent in the group aged >55 years. No significant difference was detected in overall postoperative morbidity rates. A significant difference was found in operative time and hospital stay favouring all patients who lost weight preoperatively. Most patients reported problems with redundant skin, especially on the abdomen, upper arms and rear/buttocks, which impaired daily physical activity in half of them. Excess skin was significantly associated with female gender, weight loss and ΔBMI. Patients with a WL >20 kg, ΔBMI ≥10 kg/m2 and an EWL % > 50 showed a significantly surplus skin discomfort ($p < 0.001$). Most patients desired body contouring surgery, with high or very high desire for waist/abdomen (62.2%), upper arm (37.6%), chest/breast (28.3%), and rear/buttock (35.6%) contouring.

Conclusions: LRYGB is effective and safe in superobese (BMI >50) and elderly (>55 years) patients. A preoperative weight loss >5% is recommended to improve the outcomes and reduce complications. A WL >20 kg, ΔBMI ≥10 kg/m2 and an EWL % > 50 are associated with a higher functional discomfort due to redundant skin and to a stronger desire for body contouring plastic surgery.

Key words: Morbid obesity, bariatric surgery, superobese, elderly, preoperative weight loss, body contouring, massive weight loss, body contouring indications, postbariatric surgery

TIIVISTELMÄ

Salvatore Giordano
Bariatric and Post-Bariatric Surgery: from Metabolic Surgery to Plastic Surgery Indications

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Vaasan keskussairaala

Annales Universitatis Turkuensis 2014
Turku 2014

Tausta ja tavoitteet: Lihavuuskirurgian indikaatiot ja kirurgiset menetelmät erityisryhmillä, kuten iäkkäillä (> 55 vuotta) ja ylilihavilla (BMI> 50) eivät ole vakiintuneet. Voimakas laihtuminen lihavuuskirurgian jälkeen voi johtaa vartalon epämuotoisuutta aiheuttaviin ihopoimuihin. Nämä ihopoimut voivat aiheuttaa toiminnallisia ja esteettisiä haittoja. Tämän tutkimuskokonaisuuden tavoitteena oli tutkia lihavuuskirurgian menetelmiä ja arvioida ylimääräisten ihopoimujen yleisyyttä ja niiden vaikutusta potilaaseen sekä potilaan halua vartalon muotoa korjaavaan leikkaukseen lihavuuskirurgian jälkeen.

Potilaat ja menetelmät: Tutkimuksessa verrattiin kahden tavallisimman laihdutusleikkaustyypin (LAGB - Laparoscopic adjustable gastric banding ja LRYGB - Laparoscopic Roux-En-Y gastric bypass) leikkaustuloksia. Tulokset korreloitiin body mass indexiin (BMI), ikään ja pre-operatiiviseen laihtumiseen. Lihavuuskirurgian läpikäyneet potilaat täyttivät kyselylomakkeen, jossa arvioitiin roikkuvan ihopoimun aiheuttamaa haittaa sekä kyseltiin potilaiden halua vartalon muotoa korjaaviin toimenpiteisiin.

Tulokset: Leikkausmenetelmien vertailussa ei todettu merkittävää eroa leikkauksen kestossa, sairaalassaoloajassa tai postoperatiivisten komplikaatioiden määrässä. EWL % (mean excess weigth loss %) oli kuitenkin merkittävästi suurempi LRYGB ryhmässä 6:n ja 12:n kuukauden kuluttua leikkauksesta. Leikkausaika oli merkittävästi lyhempi alle 55-vuotiailla potilailla ja leikkauksen aikaiset komplikaatiot olivat merkittävästi yleisempiä yli 55-vuotiailla potilailla. Merkittävää eroa ei kuitenkaan tullut esille post-operatiivisessa sairastavuudessa. Leikkauksen kesto ja sairaalassaolo lyhenivät merkittävästi potilailla, jotka pystyivat pudottamaan painoaan > 5 % painostaan ennen leikkausta. Suurin osa potilaista ilmoitti kokevansa ongelmia ihopoimujen vuoksi, etenkin vatsan, olkavarsien ja pakaroiden alueilla. Ihopoimut vaikeuttivat päivittäisiä toimintoja puolella potilaista. Roikkuva ihopoimu korreloi naissukupuolen, laihtumisen määrän ja ΔBMW:n (body mass index difference) kanssa. Potilaat, joilla WL (weigth loss) > 20 kg, ΔBMI ≥ 10 kg/m2 ja EWL% > 50 oli merkittävästi ongelmia ihopoimusta (p <0,001). Suuri osa potilaista halusi vartalon muotoa korjaavia toimenpiteitä, nimenomaan vatsan (62,2%), olkavarsien (37,6%), rintojen (28,3%), ja pakaroiden (35,6%) alueille.

Päätelmät: LRYGB on tehokas ja turvallinen ylilihaville ja ikääntyneille (> 55 vuotta) potilaille. Laihtuminen ennen lihavuuskirurgista leikkausta > 5% painosta on suositeltavaa, jotta tulokset paranevat ja komplikaatiot vähenevät. WL >20 kg, ΔBMI ≥ 10 kg/m2 ja EWL% >50 liittyvät merkittävään toiminnalliseen haittaan roikkuvan ihopoimun vuoksi ja lisääntyneeseen haluun postbariatrista vartalon muovausleikkauksista.

Avainsanat: Lihavuus, lihavuuskirurgia, ylilihavuus, painonpudotus ennen leikkausta, vartalon muovaus leikkauksen indikaatiot, lihavuuskirurgian myöhäistulokset.

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ABBREVIATIONS

AGB	Adjustable gastric banding
BMI	Body mass index
BPD	Biliopancreatic diversion
BPD/DS	Biliopancreatic diversion with duodenal switch
CI	Confidence interval
ΔBMI	Body mass index difference
DM2	Diabetes mellitus type 2
EW	Excess weight
EW (kg)	Excess weight in kilograms
EW (%)	Excess weight (percentage)
EWL	Excess weight loss
EWL (kg)	Excess weight loss in kilograms
EWL (%)	Excess weight loss (percentage)
GB	Gastric banding
GI	Gastrointestinal
GERD	Gastroesophageal reflux disease
HbA1c	Glycosylated haemoglobin
HT	Hypertension
JIB	Jejunoileal bypass
LAGB	Laparoscopic adjustable gastric banding
LRYGB	Laparoscopic Roux-En-Y gastric bypass
LSG	Laparoscopic sleeve gastrectomy
MGB	Laparoscopic Mini Gastric Bypass
MWL	Massive weight loss
NAC	Nipple areola complex
OSA	Obstructive sleep apnea
OR	Operation room
QOL	Quality of Life
RYGB	Roux-En-Y Gastric bypass
SD	Standard deviation
SG	Sleeve gastrectomy
VAS	Visual analogue scale
VGB	Vertical banded gastroplasty
VTE	Venous thromboembolism
WL	Weight loss

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original publications which are referred to in the text by their Roman numerals:

I Giordano S, Tolonen P, Victorzon M. Laparoscopic Roux-En-Y gastric byass versus laparoscopic adjustable gastric banding in the superobese: Perioperative and early outcomes. Scand J Surg. 2014 *in press.*

II Giordano S, Victorzon M. Laparoscopic Roux-En-Y Gastric Bypass is Effective and Safe in Over 55-year-old Patients: A Comparative Analysis. World J Surg. 2014 May;38(5):1121-6.

III Giordano S, Victorzon M. The Impact of Preoperative Weight Loss Before Laparoscopic Gastric Bypass. Obes Surg. 2014 May;24(5):669-74.

IV Giordano S, Victorzon M, Koskivuo I, Suominen E. Physical discomfort due to redundant skin in post-bariatric surgery patients. J Plast Reconstr Aesthet Surg. 2013 Jul;66(7):950-5.

V Giordano S, Victorzon M, Suominen E. Functional impairment due to surplus skin in successful post-bariatric surgery patients. *Submitted.*

VI Giordano S, Victorzon M, Stormi T, Suominen E. Desire for body contouring surgery after bariatric surgery: do body mass index and weight loss matter? Aesthet Surg J. 2014 Jan 1;34(1):96-105.

1. INTRODUCTION

Obesity is a chronic, mutifactorial disease with genetic, environmental, psycho-social, biologic, neurologic and cultural causes due to an excess of adiposity. Obesity is defined when body weight exceeds ideal body weight (IBW) by 20%, or a body mass index (BMI) of 30 kg to 35 kg/m^2. In 1991, the National Institutes of Health defined morbid obesity as a BMI of greater than 35 kg/m^2 with severe obesity-related comorbidity, or a BMI of greater than 40 kg/m2 without comorbidity (Table 1, NIH conference 1991). Obesity is further classified into different types according to BMI (Table 2, Gilbert EW et al. 2012).

In Finland, 70% of men and 56% of women are overweight (BMI 25-30), with an overall obesity prevalence (BMI >30) of 170 000 individuals (www.limery.fi). Based on the latest estimates in European Union countries, overweight affects 30-70% and obesity affects 10-30% of adults ((http://www.euro.who.int). More than one-third (34.9% or 78.6 million) of U.S. adults are obese (Odgen et al. 2014).

Many conditions that may lead to an increased morbidity and decreased life expectancy are associated with obesity. Years of life lost differ between overweight and obese groups in men and women. Percentage estimates of total deaths due to obesity vary widely, from 5% to 13% (Flegal et al. 2013), but compared with the overweight stable trajectory, the class I obesity (BMI of 30–34.9) upward and class II/III (BMI greater than or equal to 35) obesity upward trajectories are significantly associated with 30% and 147% increases in mortality risk, respectively, without controlling for confounding health factors (Table 1, Zheng et al. 2013).

Conditions associated with obesity include type II diabetes (57%), gallbladder disease (30%), hypertension, hyperlipidemia and coronary artery disease (17%), as well as osteoarthritis (14%), uniapnea, incontinence, infertility, cancers (11%), and depression in adults, adolescents and children (Aballay et al. 2013, Casagrande et al. 2014).

The most severely obese patients have various degrees of impairment of postural control and mobility dificiences. Excess weight and a long duration of sedentarism exert a negative effect on muscle strength and aerobic capacity, which are prerequisites for good mobility of the joints (Ponta et al. 2014)

Obesity increases the risk of complications and mortality in many surgical procedures because of its correlation with deficient wound healing (Pierpont et al. 2014).

Obese individuals also have an increased risk of psychological distress, body image dysphoria, disordered eating, bipolar disorder, and impaired health-related quality of life (Kubik et al. 2013, Grothe et al. 2014)

Obesity has become one of the major contributors to the global burden of disease, especially in the USA and other high-income countries of the Western world (Finucane et al. 2011).

Economic growth, global trade liberalization and urbanization, continuously lead to dramatic changes in living environments and, subsequently, in diets and lifestyles promoting a positive energy balance increasing the incidence of obesity and its related chronic diseases worldwide (Kearney 2010).

If an individual's caloric intake exceeds energy expenditure, a positive energy balance occurs and leads to weight gain.

Globalization has led to critical improvements in quality of life and food security, decreasing the level of poverty in many countries, but, on the other hand, it has led to an increased consumption of sugar-sweetened beverages and junk foods very high in energy but low in nutritional values. These factors combined with reductions of physical daily activity have driven global obesity into an epidemic disease (Fuster et al. 2010). Indeed, the costs of obesity and its associated comorbidities are extremely high for the society in terms of healthcare expenditure and reduction of quality of life, underscoring the need to increase strategies for prevention (Kelly et al. 2008, Finkelstein et al. 2009).

People in wealthy segments of the society have a lower risk of obesity than those in low-income ones, possibly because of the opportunity of benefitting from a high level of health education, a better income with which to purchase healthy foods, adequate time for physical activities, and access to quality health care (Beaglehole et al. 2011).

In obesity there is an excess of body fat, which can be distributed equally all over the body or concentrated in particular regions. There are gender differences in the distribution of body fat. Males have less body fat, which is usually distributed around the waist especially in the abdominal area, and this type of fat distribution is called android. Females normally have a higher fat percentage than men and deposit fat around their thighs and buttocks; this type of distribution is called gynoid, and, therefore, obese women tend to deposit fat in the lower part of the body.

To date, bariatric surgery is the most effective treatment for morbid obesity (Burchwald et al. 2004). The efficacy of bariatric procedures in the induction and maintenance of weight loss is largely superior to that obtainable by current medical therapies (Burchwald et al. 2004, 2009). Surgery results in greater improvement in weight loss outcomes and weight-associated comorbidities compared with nonsurgical interventions, regardless of the type of procedure used (Colquitt et al. 2014). However, the indications and outcomes of bariatric surgery in higher risk patients (superobese, elderly) are still controversial.

Massive weight loss following bariatric surgery has created a fast-growing population of patients eligible for body contouring with a unique combination of problems and an increasing demand for these procedures (Staalesen et al. 2013). Indeed, clear guidelines for treating these patients are still lacking.

Table 1. NIH Classification by Body Mass Index.

BMI (Kg/m^2)	**Class**
25-29.9	Overweight
30-34.9	Class I (low risk) obesity
35-39.9	Class II (medium risk) obesity
≥40	Class III (high risk) obesity

Table 2. Classification of Morbid Obesity.

Type of Obesity	**BMI (Kg/m^2)**
Obesity	BMI >30
Severe Obesity	BMI >35
Morbid Obesity	BMI >40
Superobesity	BMI >50
Supersuperobesity	BMI >60

2. REVIEW OF THE LITERATURE - BARIATRIC SURGERY

2.1 History of Bariatric Surgery

The origins of bariatric surgery can be dated back to the 1950s, but its practice remained unknown until obesity became a recognized epidemic disease with life-threatening comorbidities such as diabetes, hypertension, sleep apnea, dyslipidemia and venous stasis resulting in a higher risk for premature death (Adams et al. 2007, Sjöström et al. 2007).

Surgical treatment is nowadays divided into three main types according to the principle of effect:

Restrictive procedures – Adjustable Gastric Banding and Sleeve Gastrectomy; Malabsorptive operations –Biliopancreatic Diversion and Duodenal Switch; Hybrid operations – Gastric Bypass.

Although all nonsurgical attempts at weight reduction have included limiting or reducing the caloric intake, interestingly, the first surgical attempts involved malabsorption, not restriction.

Dr Viktor Henrikson from Sweden is credited to be the first to perform surgery for inducing weight loss and improving comorbidities in a case report of 1952, by removing 105 cm of the small intestine (Henrikson 1952). In 1952, Dr Richard Varco from Minnesota performed the first jejunoileal bypass (JIB) (Buchwald et al. 1987). Later, in 1963, Payne et al. published a series where the small intestine and part of the colon were bypassed. This resulted in fast weight loss, diarrhea, liver damage, and disturbance in electrolyte balance, and, after that, the anatomy had to be restored to normal (Payne et al. 1963).

After several intermediary procedure attempts (Lewis et al. 1966), the standard jejunoileal technique was established in 1969, where 35 cm of proximal jejunum was attached to the terminal ileum 10 cm from the ileocecal valve (Payne et al. 1969). Jejunoileal bypass surgery is associated with metabolic disorders causing kidney stones, abdominal bloating, migratory arthralgias, and, particularly, liver problems, up to liver failure (Scott et al. 1971, Brown et al. 1974).

Because of the morbidity following jejunoileal procedures, Prof. Scopinaro et al. from Genoa developed the biliopancreatic diversion (BPD) procedure in the mid-1970s. This procedure involved a partial distal gastrectomy with closure of the duodenal stump. The jejunum was divided 250 cm proximal to the ileocecal valve. The distal limb (Roux limb) was then anastomosed to the proximal stomach, while the proximal limb (biliopancreatic limb) was anastomosed to the ileum 50 cm proximal to the ileocecal valve. The result was a Roux-en-Y version of the JIB (Scopinaro et al. 1979). Their results are the best, in terms of initial and maintained weight loss, reported in the bariatric surgical literature to date, achieving an impressive glycemic control in diabetes patients, with a 98% cure rate at 10 years (Scopinaro et al. 1996).

To reduce some of the morbidity associated with the BPD, Hess and Marceau developed a variation of that procedure in the late 1980s, by preserving the pylorus and proximal duodenum to reduce dumping syndrome, and neutralizing gastric acid (Hess et al. 1998, Marceu et al. 1993). To date, anemia and vitamin D deficiency are the most common complications (Sucandy et al. 2013).

Looking for a weight loss operation without the deleterious side effects of JIB, Dr Edward E. Mason, from the University of Iowa, developed the gastric bypass, introducing gastric restriction as the main factor in losing weight (Mason et al. 1967). The first gastric bypass was performed by Mason and Ito in 1966, on a 50-year-old woman with a BMI of 43 kg/m^2 (Mason & Ito, 1967). The procedure consisted of dividing the stomach horizontally and connecting a loop gastrojejunostomy to the proximal gastric pouch of 100-150 ml. Nine months later, she was 27 kg lighter.

Then the volume of the proximal pouch was reduced to 50 ml to improve the results and to reduce stomach ulcers. In the Alder technique (1977), the proximal pouch was formed by stapling the stomach transversely and attaching a Roux-en-Y anastomosis onto it, reducing tension and avoiding bile reflux (Alden et al. 1977). Several modifications of this method were developed until 1994 when laparoscopic techniques were also adopted in bariatric surgery (Wittgrove et al. 1994). Laparoscopic gastric bypass became the most common bariatric surgery technique.

Restrictive procedures began in the 1970s when Mason and Printen divided the stomach into two parts horizontally leaving a small connective portion between the parts, obtaining only temporary benefits (Printen & Mason 1973). Fabito introduced a vertical gastroplasty (Fabito 1981), and Laws a silastic ring to support the opening (Laws & Piantadosi 1981). Later, in 1980, Mason developed the latest variation of gastroplasty, the vertical banded gastroplasty (VBG) almost abandoned in recent years (Mason 1982, Marsk 2009).

Laparoscopic banding technique was developed in different centres, with different devices and several modifications until, in 1985, Professor Dag Hallberg introduced an adjustable band, the Swedish Band, which gained large popularity (Hallberg 1985, Kuzmak 1985 and Forsell et al. 1993). The Kuzmak's band, known as the Lap-Band, has the same basic idea of adjustment, but the Swedish band has a low pressure, it is soft, and it can be adjusted to a greater extent (Hallberg 1985). Closer follow-up for adjustments is required to obtain optimal results; however, re-operation rates are very high in the long term (Victorzon & Tolonen 2013). Despite losing popularity, it is still a common procedure because of its reduced invasiveness (O'Brien et al. 2013).

Sleeve gastrectomy (SG) was first described by Marceau in the early 1990s as the restrictive component of the BPD/DS (Marceu et al. 1993). At the beginning, a 40-French bougie was used, but, because of unsatisfactory weight loss, the size was reduced to a 32-French bougie, which resulted in greater excess weight loss at 5.9 years (Sieber et al 2014). However, a narrow sleeve may increase the risk for severe complications, and the preferred bougie size is one of the controversial issues contributing to the poor standardisation of the procedure (Victorzon 2012). Removing the fundus area of the stomach decreases the ghrelin hormone level and reduces appetite. At present, its popularity is increasing especially in Europe and the United States (Buchwald et al. 2013).

2.2 Bariatric Surgery for Morbid Obesity

The Gastrointestinal (GI) System is responsible for the breakdown and absorption of various foods and liquids needed to sustain life. Many different organs have essential roles in the digestion of food, from the mechanical disrupting by the teeth to the creation of bile by the liver. Bile production of the liver plays an important role in digestion: from being stored and concentrated in the gallbladder during fasting stages to being discharged into the small intestine.

During digestion, two main processes occur at the same time: mechanical digestion, where larger pieces of food get broken down into smaller pieces while being prepared for chemical digestion, starting in the mouth and continuing into the stomach; and chemical digestion, which starts in the mouth and continues into the intestines. Several different enzymes break down macromolecules into smaller molecules that can be absorbed.

The GI tract starts with the mouth and proceeds to the esophagus, stomach, small intestine (duodenum, jejunum, ileum), and then to the large intestine (colon), rectum, and terminates at the anus. Bariatric surgery interferes at a different level of the digestion according to the specific technique used in order to reduce the caloric intake or absorption (Hall et al. 2010).

Restrictive operations simply reduce food and calorie intake to induce weight loss. Malabsorptive procedures decrease the absorptive surface available in the intestine by bypassing segments, reducing the amount of calories the body is able to absorb from food. In general, the more malabsorptive the procedure, the more weight loss is achieved. Percentage excess weight loss (EWL%) reached is about 46% for gastric banding (restrictive), 64% for BPD/DS (malabsorptive), and 60% for RYGB (hybrid) (Buchwald et al. 2009).

In Finland, during 2013, 888 bariatric surgery procedures were performed and LRYGB was the most common procedure, with SG the most common restrictive procedure, more common than LAGB (www.limery.fi).

2.2.1 Patient Selection

Based on National Institute of Clinical Excellence (NICE) and National Institutes of Health (NIH) guidelines, individuals with a BMI greater than 35 kg/m^2 with associated medical comorbidities or whose BMI is greater than 40 kg/m^2 are qualified candidates for bariatric surgery (NICE Guidelines 2006, NIH Guidelines 1991).

These guidelines, solely based on BMI, have lately been questioned as baseline BMI seems to show no correlation with metabolic outcome (Carlsson et al. 2012, Romeo et al. 2012). In Finland, there are two contradictory guidelines for bariatric surgery: the recommendations from the highly respected Finnish expert panel (www.kaypahoito.fi), which basically are the same as the NIH guidelines, and the indications given by the Ministry of Health and Social Affairs (www.stm.fi) claiming that without comorbidity the BMI has to exceed 45. In the light of recent findings (Carlsson et al. 2012, Romeo et al. 2012) and of a recent position statement from the international federation for the surgery of obesity and metabolic disorders (IFSO) (Busetto et al. 2014), both these guidelines seem old-fashioned/out-of-date?: more attention should be given to health risks and impact on quality of life.

Patients generally should have a chronic history of obesity with no underlying endocrine abnormality that can contribute to obesity, and nonsurgical weight loss attempts through diet and lifestyle modifications with failed results.

Access to bariatric surgery should not be denied to a patient with class I obesity associated with significant obesity-related comorbidity simply on the basis of the BMI level, which is an inaccurate index of adiposity and a poor health risk predictor (Busetto et al. 2014). Patients with class I obesity who are not able to achieve adequate weight loss after a reasonable period of nonsurgical therapy should be considered for bariatric surgery. Thus, indication for bariatric surgery in class I obesity should be based more on the comorbidity burden than on BMI levels. Comorbidities should be evaluated considering their likely response to surgery and in relation to how they can be treated by established medical therapies (Busetto et al. 2014).

On the other hand, the use of bariatric surgery should be avoided in patients with class I obesity and advanced obesity-related or obesity-unrelated comorbidities (frailty patients), in whom intentional weight loss may not have any beneficial effect on prognosis or may be harmful. Nevertheless, bariatric surgery cannot be currently recommended in children/adolescents or in elderly obese patients with class I obesity (Busetto et al. 2014).

Specifically, the use of bariatric surgery for elderly obese patients is controversial because of the higher risk of complications and poorer outcomes in term of weight loss and improvements of comorbidities (Scozzari et al. 2012).

Preoperative evaluation is crucial in order to enhance the outcomes. In particular, most patients with significant medical issues often require preoperative cardiorespiratory clearance, because all comorbidities must be optimized before surgery. Indeed, preoperative examinations are indicated to detect obstructive sleep apnea, obesity hypoventilation syndrome, and coronary heart disease. Most bariatric surgeons recommend a psychological screening to ensure that patients have no severe, untreated psychological diseases (Marek et al. 2014). Postoperative support groups are available in most bariatric centres, because patients who participate regularly in these meetings have a significantly greater weight loss (Castellini et al. 2014).

The decision to choose one bariatric procedure over another is complex and is based on factors beyond absolute patient preferences. Although maximum weight loss is a commonly reported preference for patients seeking bariatric surgery, patients with diabetes are more focused on diabetes remission. Most patients have already decided which procedure to undergo prior to surgeon consultation. Patients may benefit from shared decision making, which integrates patient values and preferences along with current medical evidence to assist in the complex bariatric surgery selection process (Weinstein et al. 2014).

The choice of the appropriate bariatric procedure is made after appropriate patient selection, extensive patient counselling, and surgeon's preferences.

2.2.2 Adjustable Gastric Banding

The operation involves laparoscopic insertion of an inflatable band, which is secured around the top of the stomach, usually placed at 1-2 cm below the gastroesophageal junction to create an approximate 30-50 ml gastric pouch to receive food (Figure 1); in this way early satiety is achieved (Belachew 1994, Tolonen 2008).

There is no alteration of the natural passage of the digestive tract and no effect on absorption so nutritional deficiencies observed are generally a consequence of inadequate intake. However, LAGB permits a relatively good medium-term weight loss, metabolic improvements, resolution or remission of obesity-related comorbidities, and improvements in quality of life, but is associated with a high reoperation rate and weight regain in the long term (Tolonen 2008, Victorzon&Tolonen 2013). Adjustable gastric banding is currently declining and has been overtaken mainly by a marked increase in sleeve gastrectomies worldwide (Buchwald et al. 2013).

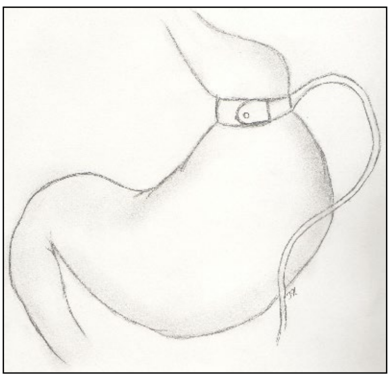

Figure 1. Adjustable gastric band.

2.2.3 Sleeve Gastrectomy

Sleeve Gastrectomy involves the removal of the greater curvature of the stomach, from the Angle of His to the distal antrum, reducing the stomach capacity by approximately 80% to a volume of 150-200 ml (Figure 2, Gagner et al. 2009).

It has recently been gaining growing popularity as a stand-alone procedure but it is also used as a first-stage procedure in high risk superobese (BMI>50) patients, followed by either RYGB or DS (Diamantis et al. 2014). The reduction in the stomach size combined with gastric tissue resection determines not only earlier satiety but also reduction of ghrelin hormone contributing to the efficacy of this procedure (Abdemur et al. 2014).

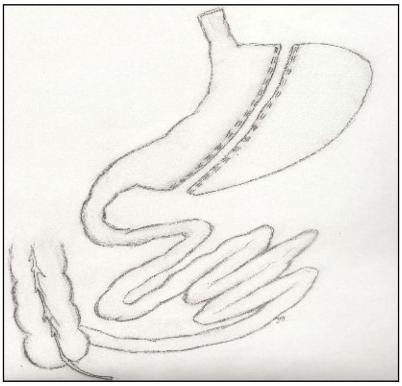

Figure 2. Sleeve gastrectomy.

2.2.4 Roux-En-Y Gastric Bypass

RYGB involves the creation of a small stomach pouch of 30 ml, which is then anastomosed to the jejunum, in order to restrict the food intake, with a Roux-en-Y alimentary limb of 100 to 150 cm and a bilio-pancreatic limb of 50 to 75 cm, whilst bypassing the distal part of the stomach, duodenum, and the proximal jejunum (Figure 3, Wittgrove 1994).

LRYGB is the most common bariatric procedure for the treatment of morbid obesity and it is considered the gold standard because of its greater weight loss and lower weight regain compared to purely restrictive interventions (Buchwald et al. 2013).

When comparing Roux-en-Y gastric bypass with sleeve gastrectomy, its superiority in terms of weight loss is less evident. Different studies showed that Roux-en-Y gastric bypass is associated with better diabetes control, but percentage of excess weight loss is comparable (Chouillard et al. 2011, Lee et al. 2011, Yaghoubian et al. 2012, Peterli et al. 2013, Helmiö et al. 2014).

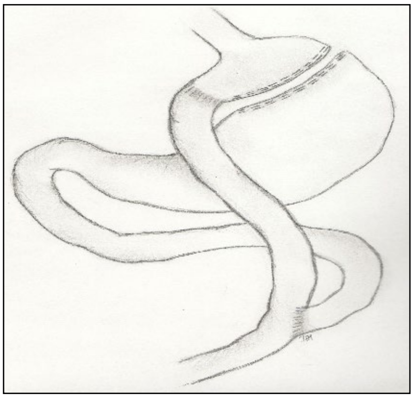

Figure 3. Roux-En-Y Gastric Bypass.

2.2.5 Mini Gastric Bypass

The Mini Gastric Bypass (MGB), also known as the Single-Anastomosis Gastric Bypass, One-Anastomosis Gastric Bypass or Omega-loop Gastric Bypass, was developed in the late 90s and first reported by Dr Robert Rutledge in 2001 (Figure 4, Rutledge 2001). This technique is considered simpler, faster and safer than the standard LRYGB, but it is also surrounded by much controversy, mainly regarding the possible harmful effects of bile reflux to the gastric pouch (Mahawar et al. 2014).

In short, five ports are used and the stomach is stapled along the lesser curvature with a calibration tube inserted and starting from the gastric incisura in order to create a long tube. The jejunum is lifted usually 200 cm from the Treitz ligament and anastomosed to the gastric tube (Figure 4, Rutledge 2001).

MGB has been reported to achieve a weight loss at least equivalent to that of the LRYGB or LSG, but with an added advantage of easy reversibility and improved safety (Noun et al. 2014).

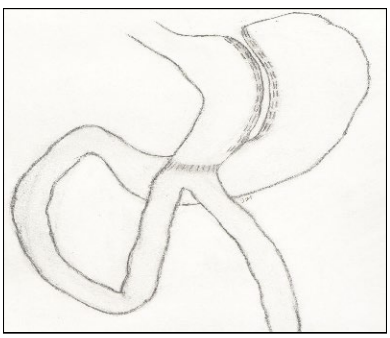

Figure 4. Mini Gastric Bypass.

2.2.6 Biliopancreatic Diversion +/- Duodenal Switch

BPD involves distal gastrectomy, leaving a 200 - 400 ml pouch, ileal transection and Roux-en-Y reconstruction with a very short common limb of 50-100cm (Figure 5, Scopinaro et al. 1996).

A variant of this technique includes a Duodenal Switch (DS), consisting of a vertical gastric pouch created with preservation of the pylorus and proximal duodenum, conserving the normal gastric emptying and improving iron and calcium homeostasis (Figure 5, Scopinaro et al. 1996).

Biliopancreatic diversion with or without Duodenal Switch results in the most rapid and sustained weight loss, with comorbidity resolution, particularly type 2 diabetes, due to significant fat malabsorption with only 28% of ingested fat and 57% of ingested protein absorbed post-operatively (Scopinaro et al. 1996, Marceau et al. 2014). However, this operation is less common because of the increased risk of malabsoptive complications (Buchwald et al. 2013).

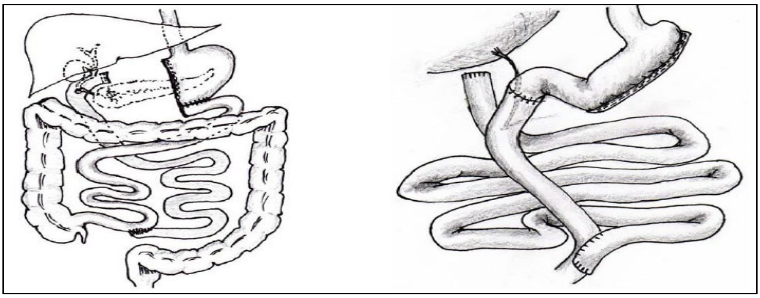

Figure 5. Biliopancreatic Diversion and Duodenal Switch.

2.3 Effects of Bariatric Surgery

Bariatric surgery is the only intervention that induces a significant weight loss in the obese population, decreasing the rate of important comorbidities' overall mortality by 45% (Pontiroli et al. 2011, Brethauer et al. 2013).

2.3.1 Weight Loss Improvements

The outcomes following bariatric surgery differ according to the different surgical procedures. According to the criteria developed by Reinhold (Reinhold 1982), an Excess Weight Loss (EWL) is considered excellent if more than 75%, good if between 50% and 75%, and fair if between 25% and 50% of excessive weight is lost. Therefore, successful bariatric surgery is obtained when a persistent EWL over 50% is reached. Weight loss usually reaches a maximum at 12-months post-operatively, but after that some weight regain is common.

When compared with each other, certain procedures resulted in greater weight loss and improvements in comorbidities than others. Outcomes were similar between LRYGB and sleeve gastrectomy, and both of these procedures had better outcomes than adjustable gastric banding. For people with very high BMI, biliopancreatic diversion with duodenal switch resulted in greater weight loss than LRYGB (Colquitt et al. 2014).

Weight loss of 5 to 10% has been associated with significant reductions in comorbidities and mortality (Maggard et al. 2008).

2.3.2 Metabolic and Gastrointestinal Improvements

Greater benefits of bariatric surgery have been reported in reduction of cardiovascular mortality and morbidity (Sjostrom et al. 2012), with reduced risk of myocardial infarction, stroke, cardiovascular events and mortality compared to nonsurgical controls (Kwok et al. 2014). Patients undergoing bariatric surgery experience improvement up to 64% and resolution of up to 50% of their hypertension (Wilhelm et al. 2014).

Excellent results have also been detected in remission and improvement of DM2 and other metabolic risk factors, with long-term complete and partial remission rates of 24% and 26%, respectively (Brethauer et al. 2013). Furthermore, shorter duration of diabetes, lower HbA1c levels and insulin independence are associated with a higher postoperative remission rate (Hayes et al. 2011).

Bariatric surgery also improves the histological appearance of the liver and can lead to regression of non-alcoholic steatohepatitis (Chavez-Tapia et al. 2010).

Concerning erectile dysfunction and infertility, weight reduction through bariatric surgery is associated with increased serum testosterone levels (Sermondade et al. 2012). In women, bariatric surgery can improve ovulatory cycles, reducing hyperandrogenism and materno-fetal risk (Maggard et al. 2008, Sarwer et al. 2014).

Emerging recent evidence suggests that weight loss through bariatric surgery may reduce the incidence of cancer, particularly in women, with a risk reduction up to 60% (Ashrafian et al. 2011, Sjöström 2013, Casagrande 2014). The mechanisms are still unclear, but they may involve mediation of inflammatory pathways and attenuation of obesity-associated hyperinsulinism and hyperandrogenism.

2.3.3 Impact of Bariatric Surgery on Obstructive Sleep Apnea, GERD and Joint Pain

Obstructive sleep apnea (OSA) and asthma are associated with important remission rates after bariatric surgery, reducing the severity of OSA more frequently than resulting in full remission, but this improvement can still leave the patient in a moderate or severe category (Greenburg et al. 2009).

Roux-en-Y gastric bypass is considered an effective method to alleviate symptoms of GERD, whereas laparoscopic sleeve gastrectomy may increase the incidence of the disease. Adjustable gastric banding was seen to initially improve the symptoms of GERD (Tolosen 2008); however, a subset of patients experienced new onset GERD symptoms during long-term follow-up (Himpens et al. 2010, El-Hadi et al. 2014).

Pain in joints, including lower back pain, is very common in obese populations and may result in loss of autonomy. Bariatric surgery can increase mobility, improve functional status and performance of daily activities, reducing levels of back pain and conferring greater levels of independence (Peltonen et al. 2003, Ponta et al. 2014).

2.3.4 Impact of Bariatric Surgery on Quality of Life and Psychological Health

Many studies have demonstrated that the quality of life (QOL) will improve significantly after bariatric surgery for individuals of varied age, ethnicity and gender, over a wide range of body mass indexes and weight changes (Helmiö et al. 2011, Mohos et al. 2011, Strain et al. 2014). Particularly, after surgery, physical and sexual function, general health, and the physical component are improved (Sarwer et al. 2014, Strain et al. 2014). On the other hand, QOL did not continue to improve any more between one and five years postoperatively, even though excess weight loss proceeded (Helmiö et al. 2011).

Depression, aggression, eating disorders and low self-concept can all be improved by bariatric surgery (de Zwaan et al. 2011), while body image dysphoria improves only sometimes. (Sarwer et al. 2010).

Improvement in body image occurs for at least two years following bariatric surgery (Sarwer et al. 2010, Zeller et al. 2011). However, there is a weak correlation between EWL and changes in QOL, maybe due to a decline in the frequency of medical consultations and visits as more time from the operation passes (Helmiö et al. 2011)

2.3.5 Economic Impact of Bariatric Surgery

Bariatric surgery results in a significant cost reduction in glycemic, lipid and antihypertensive therapy (Sussenbach et al. 2012). It is more costly than non-surgical management of obesity in the short term but a return of investment can be achieved within four years, without taking into account the increased productivity and reduced sick leave (Cremieux et al. 2008). Particularly, overall postoperative medication costs were significantly reduced one year after surgery, especially for DM2 and OSA (Gesquiere et al. 2014). Cost effectiveness may also be achieved through reduced access to healthcare system utilities because of the reduction in obesity-related comorbidities (Neovius et al. 2012). Surgery for morbid obesity increases health-related quality of life, and reduces the need for further treatments and total healthcare costs. According to a Finnish cost-utility analysis, non-operative care would be more costly for the Finnish healthcare system on an average time of five years after surgery (Mäklin et al. 2011). The Finnish Office for Health Technology Assessment (FINOHTA) evaluated bariatric/metabolic surgery in the Finnish healthcare system thoroughly and published their report in 2009 (Ikonen et al. 2009). The results of this assessment indicated that surgical treatment of patients who suffer from morbid obesity gives significant health benefits and reduces the costs for the healthcare system.

2.4 Complications following Bariatric Surgery Procedures

Surgical complications can be defined as early or late, depending on whether they occur within the first thirty days postoperatively or afterwards.

Complications can also be classified into four severity grades, the Clavien-Dindo Classification, which is commonly used (Dindo et al. 2004). Grade 1 included minor risk events not requiring therapy (with exceptions of analgesic, antipyretic, antiemetic, and antidiarrheal drugs or drugs required for lower urinary tract infection). Grade 2 complications were defined as potentially life-threatening complications with the need for intervention or a hospital stay longer than twice the median hospitalization for the same procedure. Grade 3 complications were defined as complications leading to lasting disability or organ resection, Grade 4 as life threatening complications, and finally, a Grade 5 complication indicated death of a patient due to a complication (Table 3, Dindo et al. 2004).

Greater surgical skills are associated with fewer postoperative complications and lower rates of re-operation, re-admission, and visits to the emergency department (Birkmeyer et al. 2013). The learning curve for laparoscopic bariatric surgery is associated with increased morbidity and mortality. Previous studies suggest that the learning curve has to include 100 cases to reach a morbidity rate similar to open procedures, or a significant reduction in morbidity (Søvik et al. 2009). However, the definition of learning curves in surgery is controversial, and the practical application remains to be defined (Giordano et al. 2010). Clinically relevant indicators of learning curves probably depend on the type of procedure evaluated, the institutional and surgeon's experience, and the surgical training. Rates of severe complications are inversely associated with hospital and surgeon procedure volume (Birkmeyer NJ et al. 2010), but, according to Finnish studies, bariatric surgery can be performed safely on a larger scale in a small hospital with acceptable complication and mortality rates (Victorzon et al. 2012).

Table 3. Clavien-Dindo Classification of Surgical Complications.

Grade	Definition
Grade I	Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions Allowed therapeutic regimens are: drugs as antiemetics, antipyretics, analgetics, diuretics, electrolytes, and physiotherapy. This grade also includes wound infections opened at the bedside
Grade II	Requiring pharmacological treatment with drugs other than those allowed for grade I complications Blood transfusions and total parenteral nutrition are also included
Grade III	Requiring surgical, endoscopic or radiological intervention
Grade IIIa	Intervention not under general anesthesia
Grade IIIb	Intervention under general anesthesia
Grade IV	Grade IV Life-threatening complication requiring IC/ICU management
Grade IVa	Single organ dysfunction (including dialysis)
Grade IVb	Multiorgan dysfunction
Grade V	Death of a patient

2.4.1 Mortality

Mortality rates after bariatric surgery are low (0.1% for the entire bariatric surgery and 0.15% after RYGB). Pulmonary and venous thromboembolisms are early complications and occur in less than 0.5% of bariatric surgery patients (Benotti P et al. 2014, Kruger et al. 2014). Particularly, increasing BMI, increasing age, male gender, pulmonary hypertension, congestive heart failure, and liver disease are risk factors for 30-day mortality after LRYGB (Benotti et al. 2014).

2.4.2 Leaks and Fistulas

Anastomotic leak is a feared early complication. Higher BMI, male gender, re-operation, older age and surgeon's experience are all associated with higher rates of anastomotic leakage (Smith et al. 2011). It can occur at any anastomotic junction or stapler line in RYGB, SG or BPD/BPD-DS, and may result in severe peritonitis, sepsis, and multi-organ failure. Anastomotic leakage appears most commonly at the gastrojejunostomy in RYGB and the incidence associated with mortality is 0.1% (Smith et al. 2011, Kruger et al. 2014). The incidence of leakage is 1.6-3.6% in SG, about 0.5% in RYGB, and up to 5% in BPD-DS (Simon et al. 2011, Giordano et al. 2011, Kruger et al. 2014). Gastric fistulas can occur after LRYGB, LSG, and DS, causing persistent abscess and/or distal stenosis. They are more common near the esophagogastric junction after LSG and DS. Therapeutic endoscopy with a minimally invasive approach is the treatment of choice with stricturotomy/internal drainage or endoscopic baloon dilatation (Baretta G et al. 2014).

2.4.3 Internal and incisional hernias

Internal hernias can cause bowel obstruction, and can occur at any time post-operatively. The reported frequency is about 1.6-5% for intestinal obstruction and 0.3-6% for internal hernia after LRYGB (Ortega et al. 2013). The laparoscopic approach might result in higher rates, but new surgical techniques where mesentery windows are surgically closed can reduce the incidence rate to lower than 1% (Rodriguez et al. 2010). Incisional hernias are very uncommon with laparoscopic techniques (Reoch et al. 2011).

2.4.4 Strictures

Anastomotic stricture is a late complication that can occur at any anastomotic site. The risk is higher at the gastrojejunal anastomosis with incidence rates ranging from 6-10% up to 20% (Giordano et al. 2011). The laparoscopic approach using linear staplers to make the gastrojejunal anastomosis may result in lower rates of stricture (Giordano et al. 2011). Strictures are rare after sleeve gastrectomy (1-2%) and endoscopic stenting provides a safe treatment (Vasilikostas et al. 2014).

2.4.5 Ulcers

Marginal ulcers may occur in 2% of patients within the first post-operative year, and then in 0.5% for up to five years (Bolen et al. 2012). The risk is higher in smokers.

2.4.6 Nutritional deficiencies

Deficiencies of iron, vitamin B12, folic acid, and hypovitaminosis D with development of metabolic bone diseases can occur after bariatric surgery and are mostly associated with RYGB, BPD and BPD-DS procedures, less so after SG (Bal et al. 2012). The risk of nutritional deficiencies depends on the surgical procedure performed and patient compliance during the follow up (Bal et al. 2012, Vidal et al. 2014).

2.4.7 Dumping

A variable incidence of dumping syndrome has been reported after bariatric surgery (Banerjee et al. 2013). Dumping syndrome includes early abdominal pain, diarrhea, nausea, bloating, fatigue, facial flushing, palpitations, hypotension and syncope after high glycemic index meals. It can be attributed to rapid gastric emptying or rapid exposure of the small intestine to nutrients (Tack et al. 2014).

2.4.8 Others

Other post-operative complications include gastro-esophageal reflux after LSG (up to 50%), alopecia (up to 4.5%), cholelithiasis (about 2%), and postprandial hypoglycemia (0.04%, 0.2% after RYGB; Foster-Schubert 2011, Botros et al. 2014, Tack et al. 2014).

Particularly, postprandial glycemia excursions increase after LRYGB, because of an earlier and higher peak level of glucose and a lower nadir glucose level after food intake, and can emerge years after bariatric surgery (Salehi et al. 2014).

Finally, there is some evidence that suicide rates are higher in bariatric patients than in control groups, with an estimated suicide rate of 4.1/10,000 person-years (Peterhänsel et al. 2013). Therefore, post-operative psychological monitoring is recommended in order to identify persons at risk.

3. BODY CONTOURING SURGERY

3.1 History of Body Contouring Surgery

Physical image has always been of concern to most people (Persichetti et al. 2004). Particularly, unaesthetic fat deposit or loose skin, not responding to diet or exercise, have always been major issues (Saldanha 2006).

There are gender differences in the distribution of the body fat. Males have less body fat, which is usually distributed around the waist especially in the abdominal area and this is called android fat. Females normally have a higher fat percentage than men and deposit fat around their thighs and buttocks, which is called gynoid fat. Obese women tend to deposit fat in the lower part of the body.

The excess of fat might cause psychosocial, physical and aesthetic discomfort in patients. Plastic surgery, with the performance of abdominoplasty and liposuction, has been trying for a long time to solve this problem, attempting to achieve pleasant cosmetic results (Saldanha 2006).

3.1.1 History of Abdominal Procedures

The first body contouring procedures were mostly functional panniculectomies using different approaches concerning the scar shape and location (Saldanha 2006). Over a century ago, in 1880, in France, Demars and Marx reported a large resection of skin and fat from the abdominal wall. In 1899, Dr Kelly performed a panniculectomy with an elliptical transversal incision around the umbilicus (Kelly 1899). Two years later, in 1901, Peters described similar surgery resecting a specimen of 7450 g from a patient, including the umbilicus, without undermining (Peters 1901). Gaudet and Morestin resected fat and skin with correction of an umbilical hernia, preserving the umbilicus. Then, Babcock, in 1916, described dermolipectomies using vertical incision (Babcock 1916).

The first aesthetic abdominoplasty was performed by Thoreck in 1924, with a lower horizontal excision and delayed grafting of the umbilicus (Thoreck 1924). The first undermining in abdominoplasty was utilized by Passot in 1931 (Passot 1931). In the 1950s, Vernon combined undermining, umbilical transposition and relocation, a technique still used today. Suture of aponeurosis was first applied by Callia in 1965 (Callia 1965). Pitanguy published the largest series of 300 abdominal lipectomies in 1967 involving infrainguinal incision (Pitanguy 1967). Previously, the published literature comprised mostly case reports or small series of patients.

In the early 1970s, Regnault modified the Pitanguy incision into the "W" (Regnault 1975), while the "bikini line" incision was then performed by Grazer in 1973 (Grazer 1973).

The first belt lipectomy including an extended transverse abdominal incision circumferencially was introduced by Somalo and Gonzalez-Ulloa (Somalo 1942, Gonzalez-Ulloa 1959).

3.1.2 History of Lower Body Contouring Procedures

Paralleling improvements in abdominal wall contouring techniques, other procedures aiming to reduce the excess of skin elsewhere on the body area were developed.

After Schwarzmann's demonstration of breast nipple viability on dermal pedicles (Schwarzmann E 1930); Wise's pattern (Wise 1956), Strombeck's bipedicled technique (Strombeck 1960), Skoog's nipple transposition with a lateral vascular pedicle (Skoog 1963), Lassus's vertical reduction mammaplasty (Lassus 1970), and various other authors' descriptions, breast glandular reshaping techniques were also developed in order to recreate an attractive male and female chest.

Drs Kelly and Noel showed local elliptical excisions of thigh tissue in combination with abdominal lipectomy (Kelly 1910, Noel 1926) for lower limb contouring, but it was Dr Lewis who performed the first thigh lift in 1957 using a circular resection with vertical components in order to reduce the overall thigh circumference (Lewis 1957).

In the early 1960s, Farina's "riding trousers" type of resection was described but this procedure left scars in an undesirable position (Farina 1961). Later, this technique was improved by Pitanguy with a semicircular excision, which reduced trochanteric adiposity, and medial and lateral thigh laxity at the same time (Pitanguy 1964).

Afterwards, the semicircular thigh reduction became a circular thigh reduction as shown by Regnault (Regnault el al. 1979). One of the unwanted results of these techniques was a certain amount of gluteal depression, creating a contour deformity between the iliac crest and femoral trochanter. This inconvenience was remedied by Agris, Aston, and others by filling this area using de-epithelialized skin (Agris 1977, Aston 1980).

In the early 1990s, Dr Lockwood revolutionized the contouring surgery of the lower extremity and the entire thigh-abdomen-trunk aesthetic unit by describing the anatomic features and utilizing the

superficial fascial system to anchor tissues after excisional lifting procedures (Lockwood 1991 and 1993). This anchoring technique of the medial thigh allowed a more durable lift of the inner thigh with less scar migration.

3.1.3 History of Upper Body Contouring Procedures

Attempts at upper arm body contouring surgery were made by Thorek and his contemporaries in the 1920s by primarily elliptical excisions of the skin (Thoreck 1930). However, this kind of procedure remained relatively uncommon until 1973, when Lewis carried out the resection into the axilla with a Z-plasty to reduce the effects of possible scar contractures. Later, Pitanguy developed a variant for patients with excessive lateral axillary skin, continuing the arm incision down to the inframammary fold (Pitanguy 1977). A fishtail incision variant of the arm reduction was described by Regnault and it has been slightly modified by many plastic surgeons into the multitude of techniques utilized nowadays (Regnault 1980).

3.1.4 History of Liposuction

Along with surgical resection techniques, liposuction has profoundly changed the scenery of body contouring procedures. In France, in 1921, Dujarrier attempted to remove subcutaneous fat from the leg of a dancer utilizing a uterine curette. Unfortunately, he damaged the femoral artery causing subsequent amputation of the patient's leg (Dolsky et al. 1987). Then, for many years, liposuction attempts were abandoned until 1976, when Aprad and Giorgio Fischer in Rome revisited subcutaneous fat suction using a cannula attached to a negative pressure device: they used the technique of criss-cross tunnels formation (Fischer et al. 1976).

Later, Pierre Fournier, from Paris, noticed the liposuction benefits for body contouring and initially performed the '"dry technique" (Coleman 1999). Illouz, also from Paris, performed the first "wet technique" infiltrating a solution of hypotonic saline and hyaluronidase before liposuction, noticing that a dissecting "hydrotomy" facilitated the fat removal and reduced the local trauma (Illouz 1980).

In 1987, Klein described the use of the tumescent technique and demonstrated its safety and efficacy (Kein 1987), thus changing the practice of liposuction. Therefore, liposuction and liposculpture became proven modalities to avoid noticeable scars in patients with good skin tone, and to provide an important complement to skin excision body contouring procedures.

All of the advances made in body contouring surgery, from the pioneer work of Dr Kelly and his contemporaries to the innovations seen nowadays, have contributed to a dynamic evolution of this speciality. Because of the worldwide continually rising obesity prevalence, the demand, the growth and the development of the field of body-contouring surgery is increasing. The combination of regional dermolipectomies, lifts, and liposuction can potentially restore the human form, recreate the gesture and restore an appropriate structure to the patient after massive weight loss.

3.2 Body Contouring After Massive Weight Loss

Massive weight loss (MWL) is defined as an excess weight loss (EWL) of 50% or more in an effort to combat morbid obesity (Shermak et al. 2006). A comprehensive and detailed preoperative evaluation is mandatory as the body-contouring procedures following MWL are often extensive with potential morbidity and even mortality (Michaels et al. 2011). Although this amount of weight loss is most commonly found in bariatric surgery settings, plastic surgeons should distinguish between patients who have undergone bariatric/metabolic surgery and those who have lost weight only through diet and exercise, because malabsorptive procedures produce a number of nutritional deficiencies not otherwise seen. Furthermore, they need to understand the differences between different bariatric surgical techniques and take their basic working mechanism into consideration as patients having purely restrictive procedures are less likely to suffer from many of the metabolic complications and deficiencies that may be seen after malabsorptive weight loss operations (Bossert et al. 2012).

The terms, body contouring or post-MWL body contouring, can be applied to any surgical procedures used to modify the skin envelope, subcutaneous layer, and/or investing fascia, and include a wide range of operations performed to treat the MWL patient.

After a rapid and massive weight loss, there is a sudden change in BMI which leads to skin and soft tissue becoming redundant with a poor tone. Surplus skin and malpositioned adipose deposits can contribute to medical conditions such as irritation, fungal infections, poor hygiene, skin breakdown, physical function impairments and low self-esteem (Bossert et al. 2012). Therefore, excisional surgery may relieve these symptoms and, for all these reasons, it must be considered to be reconstructive rather than cosmetic (Bruschi et al. 2009). However, MWL patients are also seeking an aesthetic outcome to improve their body image and self-esteem.

3.2.1 Medical Comorbidities and Nutritional Assessment and Weight Stability

Many morbidly obese patients have significantly improved their medical status because of bariatric surgery (Colquitt et al. 2014). However, any medical problems and psychosocial issues should be assessed and addressed before surgery with an appropriate multidisciplinary consultation in order to optimize the patient for the procedure (Gusenoff et al. 2008).

A history of dumping syndrome and its duration need to be assessed, as well as constitutional symptoms, like nausea and vomiting, because a prolonged emesis can be the sign of a mechanical problem requiring further investigations on the part of the bariatric surgeon (Bossert et al. 2012). Although vast medical improvement is seen with significant weight loss, the plastic surgeon must critically evaluate unsolved medical issues (diabetes, cardiac disease, OSA, venous thromboembolism risk, Bossert et al. 2012).

Particular attention must be paid to the patient's current prescription medication regimen. Antiplatelet and nonsteroidal antiinflammatory agents must be discontinued for at least two weeks before surgery. Specifically, the surgeon must ask about any herbal medications or nutritional supplements used by the patients (Wong et al. 2012).

The negative effects of tobacco smoke should be pointed out and, thus, surgery should be deferred for all active smokers. One month before surgery, a urine cotinine test can be administrated to prove that the patient is tobacco-free (Gravante et al. 2007, Sørensen 2012).

Preoperative appropriate nutritional assessment remains crucial. Malabsorptive deficiencies may be less common in patients previously treated by restrictive procedures. However, they might present with nutritional derangements secondary to caloric restriction (Bossert et al. 2012).

Medications and nutritional supplements, such as iron, Vitamin B12, calcium, and multivitamins, are often prescribed after LRYGB. It is important to assess the amount of daily protein intake and the perioperative goal of 70 to 100 grams per day is encouraged (Bloomberg et al. 2005). Therefore, the preoperative laboratory work-up should include metabolic and nutritional parameters, like hematocrit, hemoglobin, basic metabolic panel, and prealbumin levels, as inadequate nutrition is common among postbariatric patients presenting for body contouring (Naghshineh et al. 2010).

Finally, particular attention should be paid to previous incisions that may compromise blood flow to flaps elevated during body-contouring procedures. Hernias are common in patients who have undergone open surgical procedures (laparotomy, cholecystectomy) while still obese, and there might be a need for abdominal wall reconstruction affecting the surgical plan. Indeed, superficial venous varicosities should be considered in the patient undergoing contouring of the thigh (Bossert et al. 2012).

3.2.2 Patient Selection

In order to perform a safe body contouring, the combination of good patient selection and management of patients' expectations are crucial factors (Bossert et al. 2012).

Most postbariatric patients desire body contouring, and a number of studies have shown that from 25% up to 54%, and as many as 84.5% of postbariatric patients desire body contouring, but only 21% to 25% actually undergo these procedures (Aldaqual et al. 2012, Al-Hadithy et al. 2013, Mitchell et al. 2008, Gusenoff et al. 2008, Kitzinger et al. 2012, Staalesen et al. 2013).

Assessing candidates' weight fluctuations over time is important in order to understand whether the patient has recently gained or lost weight, or if the patient has reached a plateau. A stable weight reduces the rate of complications and leads to better cosmetic results (van der Beek at al. 2011). In terms of timing, surgery should be performed when the patient's weight is stable, with recommendations of 12 to 18 months following the bariatric operation and 4 to 6 months without weight fluctuation. Usually, the lower the BMI at the time of body contouring, the better the cosmetic result and the lower the rate of surgical complications (van der Beek at al. 2011). Therefore, patients still willing to lose weight should postpone the surgery until they reach their optimal weight for a period of at least 6 months, otherwise, sagging skin will occur again.

To date, there is no clear BMI cut-off above which surgery should be refused, but it is recommended that the upper limit for massive weight loss surgery should not exceed a current BMI of 32. BMIs higher than 32 have been associated with increased risk of complications (Rubin et al. 2012).

An attempt to define national guidelines has recently been proposed in the UK (Soldin et al. 2014), requiring a BMI <28 and/or an EWL% >75% with a weight stability of over 12 months. Similarly, in Finland, guidelines have been proposed in 2010 with a BMI cut-off of 32, but panniculectomy can be performed for improving patients' functions (Setälä et al. 2012). In Sweden, abdominoplasty in post-bariatric surgery patients is indicated if the panniculus hangs over 3 cm within a stable BMI <30, while in Denmark BMI has to be <30 and a ΔBMI>15 (Post-bariatric surgery panel: the situation in Nordic countries. In: 34th Congress of the Scandinavian association of plastic surgeons. Helsinki, 13-16 June 2012).

Plastic surgeons should be very selective when dealing with patients presenting with a BMI between 30 and 35, looking at individual patterns of body fat distribution to guide surgical planning. For example, a patient with an android body type might have a large intra-abdominal fat amount that limits an effective abdominal contouring. Similarly, patients with a BMI between 35 and 40 tend to have a thicker subcutaneous adipose layer, also limiting aesthetic contouring. Thus, for these patients, functional procedures like panniculectomy or reduction mammaplasty can improve comfort during exercise and facilitate further weight loss (Gusenoff et al. 2008, Bossert et al. 2012).

A complete evaluation of anatomic deformities is needed for planning the specific procedures. Skin redundancy and quality, lipodystrophy, and adherent folds have to be noted. Furthermore, varicose veins, lymphedema and overall scar evaluation are also important (Bossert et al. 2012).

The Pittsburgh rating can facilitate the preoperative planning and is a useful tool in quantifying the improvement after surgery with systematic assessing and quantifying of the deformities for each body region (Table 4, Song et al. 2005).

Patient expectations must be assessed at the initial patient consultation. Generally, post-bariatric surgery patients want the procedure immediately, they want perfect results, no downtime, and no risks (Gusenoff et al. 2008). Thus, patients have to be informed that body-contouring procedures are complex and labour-intensive, with big scars, long recovery times and common wound healing complications (Michaels et al. 2011). Patients presenting for postbariatric reconstruction should be aware that the procedures are mostly functional and the results may not be equivalent to an aesthetic surgery operation (Kitzinger et al. 2012).

Overall, the MWL patient population is satisfied after body-contouring surgery with an improved quality of life (Coriddi et al. 2011, Lazar et al. 2009, Klassen et al. 2012, Moderressi et al. 2013, Papadopulos et al. 2012, Singh et al. 2012, Smeets et al. 2009, Song et al. 2006), also in the long term (van der Beek 2012). However, preoperative photographs are kept in the patient record in order to show the dramatic differences in overall contour in case of issues about minor wound- healing problems, scar asymmetry, spitting sutures, seromas, and other minor complications (Song et al. 2006).

Table 4. Pittsburgh Weight Loss Deformity Scale

Area	**Scale**	**Definition**
Arms	0	Normal
	1	Adiposity with good skin tone
	2	Loose, hanging skin without severe adiposity
	3	Loose, hanging skin with severe adiposity
Breasts	0	Normal
	1	Ptosis grade 1 or 2 or severe macromastia
	2	Ptosis grade 3, or moderate volume loss, or constricted
	3	Severe lateral roll and/or severe volume loss with laxity
Back	0	Normal
	1	Single fat roll or adiposity
	2	Multiple skin and fat rolls
	3	Ptosis of rolls
Abdomen	0	Normal
	1	Redundant skin with rhytides or moderate adiposity without overhang
	2	Overhanging pannus
	3	Multiple rolls or epigastric fullness
Flank	0	Normal
	1	Adiposity
	2	Rolls without ptosis
	3	Rolls with ptosis
Buttocks	0	Normal
	1	Mild to moderate adiposity and/or mild to moderate cellulite
	2	Severe adiposity and/or severe cellulite
	3	Skin folds
Mons	0	Normal
	1	Excessive adiposity
	2	Ptosis
	3	Significant overhanging below symphysis
Hips/Lateral thigh	0	Normal
	1	Mild to moderate adiposity and/or mild to moderate cellulite
	2	Severe adiposity and/or severe cellulite
	3	Skin folds
Medial thigh	0	Normal
	1	Excessive adiposity
	2	Severe adiposity and/or severe cellulite
	3	Skin folds
Knees/Lower thigh	0	Normal
	1	Adiposity
	2	Severe adiposity
	3	Skin folds

Body dysmorphic disorder might be present in this population and must be identified before surgery, thus any patient with a psychiatric diagnosis beyond simple depression should be followed up (Sarwer et al. 2008).

Staging procedures can be beneficial in order to limit the surgical time, because longer operating times are associated with an increased rate of complications (Michaels et al. 2011). Therefore, multiple procedures can be combined safely, resulting in less anaesthetic time, less blood loss and reduced surgeon fatigue (Coon et al. 2010). Great effort should be applied to understand which anatomic areas are of greatest concern to the patient. A typical approach to staging for massive weight loss desiring total body contouring includes, firstly, lower body lift including breast or arm procedures, followed by medial thigh and upper back surgery. Facial rejuvenation procedures are performed last (Coon et al. 2010).

The patient's highest priority body areas should be addressed and treated first and a period of at least 3 months between stages is recommended.

3.3 Body-Contouring Procedures

Body-contouring procedures following MWL can be divided into lower body lift or belt lipectomy, thigh lift, brachioplasty, upper body lift, and breast reshaping. Venous thromboembolism prophylaxis includes the use of compression device, flexing the knees on a pillow, and, more important, postoperative administration of low-molecular-weight heparin or unfractionated heparin (Shermak et al. 2007, Reish et al. 2012). Intraoperative fluid management should be monitored continuously by blood pressure, urinary output and estimated blood loss (Michaels et al. 2011). Hemoglobin level should be checked during surgery or in the recovery room immediately after surgery, because these patients might present an important blood loss (Montano-Pedroso et al. 2013). Indeed, post-bariatric patients have an elevated risk for hypothermia, so it is important to maintain a normothermic temperature and reduce the time of exposure. Finally, operative time should preferably be kept under 6 hours to minimize complications (Coon et al. 2012).

Patients should be restricted to bed for the first day before assisted ambulation is encouraged. Although many surgical operations can be performed safely without prophylactic drainage, drain placement following post-bariatric surgery procedures is recommended to prevent or reduce seroma formation (Shermak et al. 2007, Kosins 2013). Timing of drain removal is the surgeon's choice as there is no evidence at present about this issue (Kosins 2013).

Overall risk for venous thromembolism is about 2.9% for all patients undergoing body-contouring surgery. This rate can increase to 8.9% for patients with a BMI >35 (Shermak et al. 2007). All patients should be treated with intermittent pneumatic compression devices applied before the induction of general anesthesia, and consideration should be given to the use of unfractionated or low-molecular-weight heparin the night of surgery or during the postoperative period on the basis of established risk factors (Pannucci et al. 2011).

Edema is particularly common after surgery on the arms or legs especially after extended thigh lifts. Compressive wrapping from distal to proximal and elevation may be performed by the patient. Good nutrition is crucial after large excisional lifting procedures. Protein and vitamin intake should be optimized, as well as patient hydration (Michaels et al. 2011).

Postbariatric surgery procedures are mostly clean surgery, therefore, antibiotic prophylaxis is only indicated when the operation lasts more than 3 h and/or the American Society of Anesthesiologists (ASA) score is 3 or more (Toia et al. 2012).

Postoperative pain management should be carried out through the use of multimodal analgesia, but other modalities such as regional blocks, pain pumps, and patient positioning should also be considered (Constantine et al. 2014).

3.3.1 Brachioplasty

Traditional brachioplasty includes incisions along the length of the upper arm, worked out within the axilla, and, for bat-wing deformity, it can continue along the lateral chest wall (Hurwitz et al. 2006). Markings are drawn with the arm elevated at 90 degrees; they are guided by pinch test along the arm and may require intraoperative modification. An additional liposuction should be limited, because it may exacerbate skin laxity. Incision is often in the antebrachial groove, with deepening to the fascia overlying muscle and neurovascular structures, taking care to avoid injuries to the medial antebrachial cutaneous nerve, near the basilic vein in the distal third of the arm (Figure 6, Chowdhry et al. 2010).

Figure 6. Brachioplasty

3.3.2 Upper Back Lift

Upper back lift is indicated in patients with an important upper back skin laxity. It is best performed at a different time from lower body lift because of opposing lines of tension (Shermak 2008). Markings are made, with the patient standing, across the upper back and the distance between them is determined by pinch test and scar location. Intraoperatively, first the patient is turned prone with arms at no greater than 90 degrees to avoid tension closure and the upper incision is made, and the back tissue is elevated inferiorly from the deep fascia. The amount of tissue removal is guided by the preoperative marks. Drains are placed laterally on each side and the incisions are sutured in layers. Then the patient is turned to a supine position in order to taper the back closure anteriorly (Figure 7, Shermak 2011).

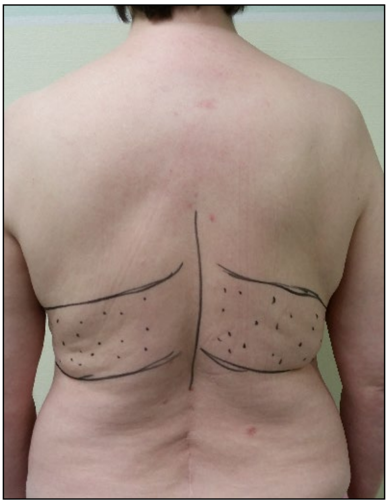

Figure 7. Upper Back Lift

3.3.3 Breast Reshaping

Breast deformities in post-bariatric surgery patients can be different and very challenging. Usually, the main problems to be addressed are the ptosis, the loss of volume and the redundant skin. Volume loss is proportional to weight loss and the amount of residual gland determines the surgical choice. If the volume left is considered enough, a gland reshaping can be performed. If a volume increase is considered advisable, then a mammary implant is necessary (Migliori et al. 2010). Round block techniques with or without implants are indicated in case of minor ptosis with a periareolar incision approach (Hammond et al. 2007), including a complete undermining of glandular upper pole in order to lift the breast, while the lower pole is left undetached in order to guarantee a good blood perfusion. In case of important ptosis (over 6 cm), the L-technique is advisable, using a superior pedicle to support the nipple areola complex (NAC) and breast suspension reducing and emphasizing the volume. Autoprosthesis can be used to increase the breast volume, de-epithelializing and harvesting flaps from the inferior or lateral part of the trunk and inserted in a pocket between the breast and the pectoralis major muscle fascia. If autoprosthesis cannot be performed and an implant is unavoidable, all the mammary glandular tissue should be harvested on a superior pedicle (Figure 8, Migliori et al. 2010).

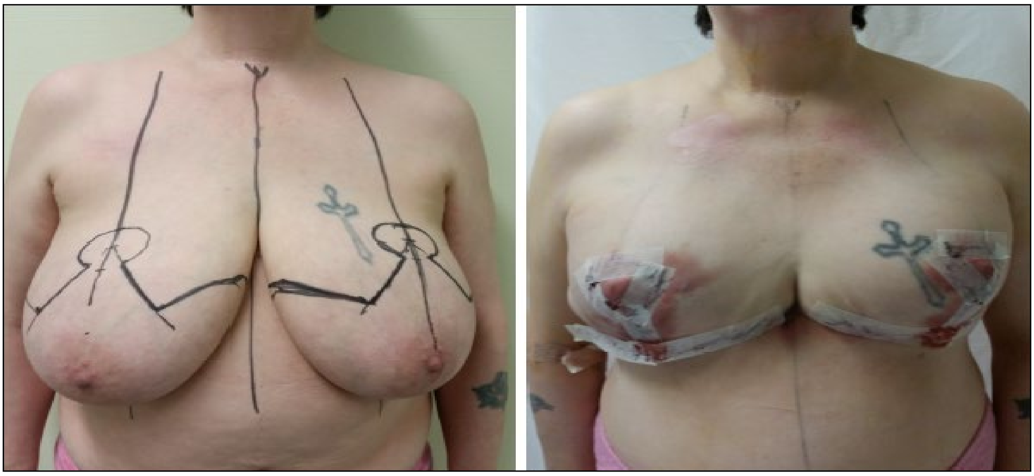

Figure 8. Breast Reshaping

3.3.4 Abdominoplasty

Indications for surgery include significant truncal skin redundancy and circumferential lipodystrophy, but abdominoplasty does not treat lipodystrophy in the peritoneal cavity. Lower back lift is first performed if a lower body lift/belt lipectomy is planned.

The patient is marked, in a standing position, with a mark on the pubis 7 cm above the pubic cleft. Incision is extended from hip to hip along the upper lateral thigh to the waist (Eisenhardt et al. 2012). An upper mark is estimated crossing the umbilicus. An additional liposuction may be performed at the same time. The surgery is performed with the patient in a supine position. Incisions are first made in the suprapubic area according to the preoperative markings, then around the umbelicus. Dissection is carried out through subcutaneous fat to the rectus fascia, up to the xiphoid, taking care to spare soft tissue pads over the femoral triangles (Shermak 2011).

If diastasis of rectus muscle is observed, midline plication of the abdominal wall is performed with no 1 braided permanent suture. If hernias have been detected, they should be repaired at the same time as body-contouring procedures for the lower trunk. Particular attention should be taken if scars of previous abdominal procedures are present, because they require special adjustments in planning and performing the procedure. Then the new umbilical position is marked and the excess of skin is removed in order to obtain an approximation without significant skin tension. Skin closure is performed in layers with drains (Figure 9).

Figure 9. Abdominoplasty.

3.3.5 Panniculectomy

Some obese or post-bariatric surgery patients may present with a panniculus morbidus, a pannus hanging down to the floor. This excess pannus can limit exercise capabilities, restrict hygiene, and may progress to a pathologic entity including intertrigo, cellulitis, skin ulceration and ischemic panniculitis (Friedrich et al. 2008). In extreme cases, a panniculus can have recurrent infections, ulcerate, and even necrose, requiring an emergency procedure.

Therefore, panniculectomy can be an adjuvant to bariatric surgery and it can be beneficial for many patients undergoing weight reduction surgery, either done at the same time as bariatric surgery or later after significant weight reduction (Acarturk et al. 2004).

With the patient preferably standing upright, the pannus is marked at the superior border to define the proposed extent of the elliptical resection. Using preoperative markings as a guide, the skin incision is started along the superior marks. The incision is then extended down through the subcutaneous fat layer and the dissection continues down to a plane superficial to the anterior abdominal fascia (Zannis et al. 2012). Contrary to abdominoplasty, the upper abdominal flap is not undermined and the umbilicus can not be preserved. Wound closure is performed in layers with drains (Figure 10).

Figure 10. Panniculectomy.

3.3.6 Lower Back Lift

Lower back lift is usually performed when patients present with back skin laxity. Very often they have “saddlebag” collections of fat, so an additional liposuction will improve the contour and enhance the thigh lift (Aly et al. 2003). It is generally performed together with abdominoplasty for a circumferential belt lipectomy or lower body lift. Performing a gluteal reconstruction is crucial in order to avoid a flat buttock without waist definition (Centeno et al. 2008). The patient is marked in the standing position. Superior and inferior marks are drawn across the lower back, and the distance between them is determined by pinch test and ultimate scar location. The marks are tapered anteriorly into abdominoplasty markings for a circumferential belt lipectomy or into thigh-lift marks. If gluteal augmentation is planned, the proposed gluteal flaps are drawn between these marks and need to be low enough to allow rotation low into the buttock region (Pascal et al. 2002).

The procedure is first performed with the patient in a prone position, incisions are carried out to the deep fascia according to preoperative marks and excess tissue is elevated. Tailor tacking is always advisable to determine the tissue to be removed. If auto-gluteal augmentation is planned, the gluteal flaps are deepithelialized and pockets are designed over the gluteal muscles where the flaps will be rotated (Pascal et al. 2002). The patient is then turned into the supine position for the abdominoplasty. Thigh lift may also be performed at the same time, constituting a total lower body-lift procedure (Figure 11, Shermak 2011).

Figure 11. Lower Back Lift.

3.3.7 Thigh Lift

Patients with laxity of the upper half of the thigh and good skin quality are good candidates for proximal thigh-lifting procedures, with scars hidden in the groin creases. However, if the skin excess of the thigh extends from the pubis, an extended thigh lift is indicated (Shermak et al. 2009).

Patients are marked in a standing position. The groin creases are marked symmetrically along the mons pubis edge and the outer portion of the crescent excision is guided by pinch test to delineate the skin to be removed. The incisions may continue posteriorly into the infragluteal crease and superiorly into the abdomen to increase the skin removal. In case of the extended procedure, vertical incisions are also marked along the inner thigh, guided by pinch testing (Shermak et al. 2009).

The patient is in a supine position with the legs stabilized on the spreader bars during the procedure. The skin is removed over the fascia overlying the thigh muscles according to the preoperative marks, and soft-tissue padding is conserved on the ischial bone. The inferior thigh skin flaps are approximated from Scarpa's fascia layer (superficial fascial system) to the ischial periosteum using no. 1 braided permanent suture with an adequate periosteal bite ensuring fixation (Figure 12, Kenkel et al. 2008).

Figure 12. Thigh lift.

3.4 Postoperative Complications

Post-bariatric surgery patients have a 60-87% increased risk of complications compared with non-bariatric patients for body-contouring procedures after massive weight loss (Hasanbegovic et al 2014). The most common complications seen after surgery include wound-healing problems, seromas and lymphoceles, infections, venous thromboembolism (1-9.3%, Michels et al. 2011, Reish et al. 2012), hypothermia (<35°C, Coon et al. 2012), lymphedema, hematomas, and nerve injury. Wound-healing problems are the most frequent after body-contouring procedures and they more often occur in patients with obesity, diabetes, endocrine disorders, Ehlers-Danlos syndrome and autoimmune disease, advanced age, peripheral vascular and coronary artery disease (Albino et al. 2009, Michels et al. 2011, Rieger et al. 2008).

Multiple comorbidities, presence of bleeding disorders, preoperative albumin level and malnutrition have recently been significantly associated with increased odds of minor wound complications (Naghshineh et al. 2010, Fischer et al 2013), while inpatient procedures and functional status have been linked with an increased odds of major surgical morbidity (Fischer et al 2013).

3.5 Benefits of Body-Contouring Surgery after Massive Weight Loss

Patients experience an improved quality of life, self-esteem, sexual life and body image after body-contouring surgery, (Azin et al. 2014, Coriddi et al. 2011, Klassen et al. 2012, Lazar et al. 2009) also in the long run (van der Beek et al. 2012, Modarressi et al. 2013). Only one recent study (Singh et al 2009) showed that patients electing to have body contouring after bariatric surgery had decreased quality of life even after plastic surgery compared to those patients who did not. This finding was probably due to unrealistic expectations. Nevertheless, body-contouring surgery not only improves the aesthetic outcomes but also corrects the functional impairment due to redundant skin (Papadopulos 2012, van der Beek et al. 2012). Furthermore, it has also been demonstrated that patients with body contouring present with better long-term weight control after Roux-en-Y gastric bypass (Balagué et al. 2013). However, no correlation has been found between the amount of weight loss and the improvement of quality of life.Therefore, for all these reasons, body-contouring surgery should be considered as a reconstructive operation in the treatment of morbid obesity in selected patients after massive weight loss.

4. AIMS OF THE STUDY

1. To compare the early outcomes and peri-operative complications of LRYGB and LAGB operations in super-obese patients (BMI >50 kg/m^2).

2. To compare the efficacy and safety of LRYGB in ≥55 year old bariatric surgery patients and to examine the role of preoperative age as a potential predictor of weight loss outcome.

3. To evaluate and compare the efficacy and complications of LRYGB in patients who lost <5%, >5% ≤10%, and >10% of their weight before surgery.

4. To evaluate the perceived incidence and location of redundant skin after bariatric surgery procedures and its related impairment of daily activities and patients' characteristics associated with such a complication.

5. To investigate the perceived incidence and location of surplus skin after massive weight loss in successful post-bariatric surgery patients (%EWL >50) and to compare those data with patients' postoperative characteristics.

6. To analyse patients' desire for body contouring after bariatric surgery procedures, to assess which body regions were associated with the greatest levels of dissatisfaction, to summarize patients' expectations from post-bariatric procedures, and to correlate these subjective reports with patients' demographic characteristics, postoperative body mass index (BMI), amount of weight loss, and difference in BMI (ΔBMI).

5. PATIENTS AND METHODS

5.1 Patients

All the following studies were carried out at Vaasa Central Hospital in different periods. Data were retrieved from a prospective database.

5.1.1 Study I

Between 2006 and 2009, 733 consecutive patients underwent laparoscopic bariatric surgery. Of these patients, 181 were classified as superobese (BMI>50, Table 2, Gilbert EW et al. 2012), had undergone either LRYGB or LAGB, with a minimum follow-up of 12 months, and were without previous bariatric procedures (revisional surgery excluded). All patients were operated in the Department of Surgery between 2002 and 2010. Patients were divided into two groups on the basis of the procedure. The mean age (± Standard Deviation) of the LRYGB group and the LAGB group was 42.6±11.43 and 41.0±9.61 years, respectively, while 91.1% and 74.7% of the patients suffered from at least one of the most typical co-morbid conditions associated with heavy overweight.

5.1.2 Studies II and III

The patient population in study II included a total of 549 patients who had undergone LRYGB between 2006 and 2012: 174 (26.98 %) of them were aged ≥55 years. They were divided into two groups using a cut-off of 55 years (Lynch et al. 2012). The mean age of group I (<55 years) was 41.15±8.47, and of group II (≥55 years) 59.43±3.81 years, while 89.66% and 97.73%, respectively, suffered from at least one of the most typical comorbid conditions associated with morbid obesity.

In study III, between 2002 and 2010, 629 patients underwent LRYGB, of whom 548 patients (87.12%) who lost at least 1 kg of weight preoperatively were included, and they were divided into three groups on the basis of the amount of preoperative weight loss: group A lost ≤5%, group B lost >5 to ≤10%, and group C lost >10% of their weight preoperatively. One or more of the most typical comorbid conditions associated with heavy overweight was present in 90.4% of the patients. A medically supervised weight management programme was not mandatory. However, patients were encouraged to follow a very low calorie diet for 2-4 weeks preoperatively, aiming at an approximately 8% weight loss before surgery.

Hypertension (HT) before surgery was defined as blood pressure persistently at or above 140/90 mmHg. Diabetes Mellitus Type 2 (DM2) was defined as a glycosylated haemoglobin (HbA1c) of greater than 7%.

5.1.3 Studies IV, V and VI

Patients included in studies IV, V, and VI had undergone bariatric surgery for morbid obesity at Vaasa Central Hospital between 2002 and 2010. Of these, 524 patients had maintained a stable weight for at least one year, and had not undergone any previous body-contouring procedures. Therefore, patients who had undergone massive weight loss (MWL) without bariatric surgery were excluded. A stable weight was defined as weight with a maximum fluctuation of ± 5 kg from the weight measured at the bariatric surgery follow-up.

In study V, patients were divided into two groups using a cut-off of %EWL >50, which represents a successful bariatric surgery weight loss, according to Reinhold´s criteria (Reinhold 1982).

Mean age was 51.24 years, mean postoperative follow-up was 56.1 months, mean weight loss 35.2 kg and mean BMI difference (ΔBMI) 12.41 kg/m^2, with a mean %EWL of 60.33.

Of all included patients 47% had undergone LAGB, 7% Sleeve Gastrectomy and 46% LRYGB or duodenal switch.

5.2 Methods

5.2.1 LAGB technique

The surgical technique used for LAGB was the "Tolonen technique", also and only later known as the "pars flaccida" technique. A broad, low pressure band, the Swedish adjustable gastric band (Obtech, Baar, Switzerland, later and now associated with Ethicon Endo-Surgery) was used and the operative technique has been described in detail (Victorzon&Tolonen 2000, Tolonen 2008).

5.2.2 LRYGB technique

LRYGB was performed using a 5-trocar technique with linear staplers and a double loop technique as earlier described by Olbers et al. (Olbers et al. 2003). Biliary limb was measured to 75 cm, and Roux alimentary limb to 150 cm. The mesenteric defects were closed using non-absorbable running sutures. No drains were routinely placed. Thirty patients were operated on using a circular stapler (Giordano et al. 2010).

5.2.3 Perioperative management

Patients were treated by a fast track pathway as introduced by Kehlet et al. (Kehlet et al. 2005 and 2008). Fast-track surgery consists of a protocol of evidence-based techniques to reduce surgical trauma and postoperative stress by minimizing pain, reducing complications, improving outcomes, and decreasing hospital length of stay, while expediting recovery following elective procedures (Kehlet et al. 2005 and 2008). Patients planned for surgery visited the outpatient clinic one week before the scheduled operation. They arrived at the clinic in the morning of the operation and were guided to the Operation Room (OR). In the OR, patients were equipped with pneumatic anti-thrombotic stockings and received Cefuroxime 1.5g antibiotic prophylaxis during induction of the anesthesia. No urine catheters were used. All patients were extubated immediately after surgery and were asked to move by themselves from the OR table to the bed. They were admitted to the surgical ward after follow-up in the awakening room for 4 – 6 hours. A liquid diet was initiated immediately the patient was fully awake, usually after 2 -3 hours, if no signs of complications could be detected. Patients were also encouraged to stand up and walk a few steps at this time. They were discharged the following day, if no signs of complications could be noted. Anti-thrombotic agents were not used routinely. The patients were followed up at regular intervals postoperatively, with the first outpatient visit at 3 months after surgery.

5.2.4 Questionnaire

For the studies IV and V, a previously developed self-report questionnaire (Bjöserud et al. 2011) was modified by the authors for the purposes of this study and mailed to 524 patients, who met the inclusion criteria (Figure 13). It contained questions on demographics (age, gender, height, weight pre- and post-bariatric surgery) and items to investigate whether the patients experienced physical problems with surplus skin after bariatric surgery (in face, upper arm, upper back, chin/neck, chest/breast, waist/abdomen, lower back, rear/buttock). Any inconvenience of surplus skin was scored using a visual analogue scale (VAS), consisting of a 10-cm horizontal line, ranging from no inconvenience at all (0 mm) to the worst conceivable inconvenience (10 cm); and the degree of daily impairment due to redundant skin (none, very low, low, somewhat, high, very high).

For study VI, a Post-Bariatric Surgery Appearance Questionnaire previously developed (Mitchell et al. 2008) and modified for the purposes of the study was used (Figure 14). It contained questions on demographics (age, gender, weight pre- and post-bariatric surgery), level of desire for body contouring per area (face, upper arm, upper back, chin/neck, chest/breast, waist/abdomen, lower back, rear/buttock) and scored from 0 to 3 (do not want, want somewhat, want, want a great deal); and degree of expectation from body-contouring surgery related to improvement in their appearance (none, very low, low, somewhat, high, very high).

Questionnaires data were compared with patient characteristics, type of bariatric procedure, amount of weight loss, BMI at follow-up, ΔBMI and %EWL. Patients were divided into groups based on the amount of weight loss, ΔBMI and %EWL. Particularly, we hypothesized that patients who lost over 50 kg and/or had a ΔBMI over 20 kg/m^2 or

%EWL >50 have greater problems due to the surplus skin after massive weight loss and a greater desire for body-contouring surgery procedures.

Patient Excess of Skin Disability Questionnaire

Age__________Sex __

Height ___ cm

Weight before bariatric surgery __kg

Weight at the present ___kg

1. How much discomfort does the excess of skin cause you?
   - Face ☐ 0__________10
   - Chin/neck ☐ 0__________10
   - Upper arm ☐ 0__________10
   - Upper back ☐ 0__________10
   - Chest/breast ☐ 0__________10
   - Waist/abdomen ☐ 0__________10
   - Lower back ☐ 0__________10
   - Rear/buttock ☐ __________10
2. How much does the excess of skin impair your daily functioning ?
   None ☐ Very low ☐ Low ☐ Somewhat ☐ High ☐ Very high ☐

Figure 13. Questionnaire concerning redundant skin impairment.

Patient Desire Questionnaire

Age__________Sex __

Height ___cm

Weight before bariatric surgery __kg

Weight at the present ___kg

1. Where would you like to have a body contouring procedure?
   - Face ☐ Do not want ☐ Want somewhat ☐ Want ☐ Want a great deal ☐
   - Chin/neck ☐ Do not want ☐ Want somewhat ☐ Want ☐ Want a great deal ☐
   - Upper arm ☐ Do not want ☐ Want somewhat ☐ Want ☐ Want a great deal ☐
   - Upper back ☐ Do not want ☐ Want somewhat ☐ Want ☐ Want a great deal ☐
   - Chest/breast ☐ Do not want ☐ Want somewhat ☐ Want ☐ Want a great deal ☐
   - Waist/abdomen ☐ Do not want ☐ Want somewhat ☐ Want ☐ Want a great deal ☐
   - Lower back ☐ Do not want ☐ Want somewhat ☐ Want ☐ Want a great deal ☐
   - Rear/buttock ☐ Do not want ☐ Want somewhat ☐ Want ☐ Want a great deal ☐
2. How much would a body-contouring procedure improve your appearance?
   None ☐ Very low ☐ Low ☐ Somewhat ☐ High ☐ Very high ☐

Figure 14. Questionnaire concerning the desire for body-contouring surgery.

5.3 Ethics

Approval for all the studies was applied for from the local Ethical Committee of Vaasa Central Hospital and granted.

5.4 Statistical analyses

For studies I, II and III, the results of parametric and nonparametric distributed data were expressed as mean ± standard deviation (SD), and IBM SPSS statistical software (IBM SPSS 20.0.0.1, Chicago, Illinois 60606, U.S.A) was used for all statistical analyses. Confidence intervals were set at 95%. A two-sided P value of ≤ 0.05 was considered as statistically significant. Comparisons between both groups were determined using Fisher's exact test for discrete variables and Student's t-test for continuous variables.

Univariate association between patients' age, preoperative weight loss, and the other variables were evaluated with Pearson's correlation coefficient.

In study I, a post-hoc statistical power of 0.184 was calculated for the two-tailed hypothesis for the continuous outcome measures, while a post-hoc statistical power of 0.292 was calculated for discrete variables with an observed effect size (Cohen's d) of 0.159.

In study II, a post-hoc statistical power of 0.999 was calculated for the two-tailed hypothesis for the continuous outcome measures, while a post-hoc statistical power of 0.359 was calculated for discrete variables with an observed effect size (Cohen's d) of 0.223.

For studies IV and VI, categorical variables were characterized by frequencies and percents, and continuous variables by means and standard deviation (SD). Statistical analyses were performed using linear models in which degree score of physical discomfort due to redundant skin or desire score for body-contouring surgery were used as dependent variable and postoperative BMI, ΔBMI, sex, age and weight loss were used as a fixed effect. P-values were adjusted using the Tukey-Kramer method in pairwise comparison between different classes of ΔBMI and weight loss amount. Residuals were checked for justification of the analysis. P-values less than 0.05 were considered as statistically significant. Statistical analyses were carried out using SAS system for Windows, Version 9.2 (SAS Institute Inc, Cary, NC, USA). For study V, univariate association between the different variables was evaluated using Pearson's correlation coefficient. Comparisons between both groups were determined using Student's t-test for continuous variables. Confidence intervals were set at 95%, and a two-sided P value of ≤ 0.05 was considered as statistically significant.

6. RESULTS

6.1 Study I. LRYGB versus LAGB in superobese patients

There were no significant differences in operative time (93.51±33.32 versus 87.72±39.24 minutes), conversion rates (0% in both groups), or hospital stay (2.68±2.27 versus 2.75±1.84). Six patients (5.9%) in Group 1 (superobese LRYGB patients) had intra-operative complications due to anastomotic or gastric pouch leak during intraoperative leak testing with methylene blue (three patients), bowel perforations due to stapler, iatrogenic injury (two patients), and one case of anvil detachment from gastric tube in the upper esophagus (a circular stapling gastrojejunal anastomosis was performed) that needed intraoperative gastroscopy. However, all intra-operative complications were managed without further sequel. No intra-operative complications occurred in Group 2 (superobese LAGB patients, 0.0%), showing a significant difference (p=0.04).

There were no significant differences in overall early postoperative complication rates between the groups, although the LRYGB group had a higher early morbidity rate (20.59% versus 15.19%, p=0.44) compared to the LAGB group. Clavien-Dindo grade III complications were significantly higher in the LRYGB group (p=0.01, Table 5). Mostly, complications included wound infections, haemorrhage, anastomosis leakage or stricture (Table 5).

Table 5. Postoperative complications < 30 days.

	Group 1 (n=102)	*Group 2 (n=79)*	*P-value*
Patients with complications (%)	18 (17.65%)	8 (10.12%)	0.200
Overall number of complications	22 (20.59%)	12 (15.19%)	0.438
Complications			
Clavien-Dindo grade I			0.608
Wound infection	6	6	
Hypotension	1	1	
Wound breakdown	1	1	
Anuria	1	0	
Tachycardia	0	1	
Clavien-Dindo grade II			1.000
Haemorrhage	4	1	
Pneumonia	1	2	
Clavien-Dindo grade III			0.010
Anastomotic leak	3	-	
Anastomosis stricture	3	-	
Ulcus marginalis	2	-	
Clavien-Dindo grade IV			
None	0	0	
Clavien-Dindo grade V			
None	0	0	

The mean WL, BMI and mean EWL% at 6 and 12 months are summarized in Table 6. Weight loss after LRYGB compared to that following LAGB was significantly greater at both 6 and 12 months' follow-up. Similarly, BMI at 6 and 12 months was significantly lower after LRYGB. The %EWL mean values were significantly higher at 6 and 12 months in favour of the LRYGB group (Table 6).

Table 6. Comparison of weight loss outcomes Group 1 (LRYGB) and Group 2 (LAGB) patients.

	Group 1 (n=102)	*Group 2 (n=79)*	*P-value*
Weight loss at 6 months (Kg))	40.82±12.55	21.57±10.17	<0.001
Weight loss at 12 months (Kg)	50.39±21.60	28.43±14.48	<0.001
BMI at 6 months (Kg/m^2)	43.57±6.66	46.06±5.37	0.012
BMI at 12 months (Kg/m^2)	34.96±13.28	41.75±11.58	0.008
EWL at 6 months (%)	44.75±11.84	26.20±12.42	<0.001
EWL at 12 months (%)	54.71±18.18	31.55±19.79	<0.001

6.2 Study II. LRYGB in <55 year-old versus >55 year-old patients

A significant positive correlation was detected between age and the length of operative time (r = 0.109, p = 0.013) and occurrence of intraoperative complications (r=0.138, p<0.001), whereas there was no significant correlation between age and postoperative complications (r=0.06, p=0.162). When correlating age with WL, EWL%, and BMI, we found a significant correlation only between younger age and WL at 1 and 2 years (r= - 0.199, p=0.004 and r= - 0.313, p=0.001, respectively), but not with EWL% at 1 and 2 years' follow-up (r= - 0.083, p=0.228 and r= 0.098, p=0.309 respectively).

Significant differences between groups in favour of younger patients were found in operative time, conversion rates, and intraoperative complications but not in hospital stay (Table 7).

One death occurred in the younger group (<55 years) 3 weeks after the operation as a consequence of severe septic complications following rupture of the bypassed stomach (blowout) on the third postoperative day.

There were no significant differences in overall early postoperative complication rates between the groups, although the elderly group had a higher rate (25.76% vs. 18.70%, p = 0.079, Table 8) compared with younger patients. Clavien–Dindo grade III complications (Dindo D et al. 2004), defined as complications requiring surgical, endoscopic, or radiologic intervention, occurred similarly in both groups (5.75% vs. 6.82 %, p = 0.675; Table 8).

The mean WL, BMI, and mean EWL% at 6, 12, and 24 months are summarized in Table 9. No statistically significant differences were detected in WL, BMI, or EWL% between the groups. The rate of patients aged >55 years reaching an EWL% of >50 % was 67.35

versus 77.71 % in the younger group (p = 0.186) at 1-year follow-up. Among older patients, 75.86 % reached an EWL% of >50% at 24 months after LRYGB compared with 72.84 % of the younger patients (p = 0.811).

However, DM2 and HT rates were still significantly higher in the elderly group (Table 9) compared with the younger.

Table 7. Comparison of peri-operative parameters between the groups.

	Group <55 years (n=417)	*Group ≥55 years (n=132)*	*P-value*
Operative time* (minutes)	84.19±29.05	90.89±30.95	0.028
Conversion to open	1 (0.24%)	3 (2.27%)	0.044
Intra-operative complications	22 (5.27%)	19 (14.39%)	0.001
Hospital stay* (days)	2.33±2.59	2.63±3.08	0.290

Table 8. Postoperative complications < 30 days.

	Group <55 years (n=417)	*Group ≥55 years (n=132)*	*P-value*
Patients with complications (%)	64 (15.34%)	28 (21.21%)	0.116
Overall number of complications	78 (18.70%)	34 (25.76%)	0.079
Complications			
Clavien-Dindo grade I			0.108
Wound infection	27	13	
Wound breakdown	1	1	
Hypotension	1	1	
Anuria	0	1	
Tachycardia	1	0	
Urinary infection	1	0	
Clavien-Dindo grade II			0.518
Haemorrhage	19	5	
Pneumonia	3	1	
Embolia	0	2	
Subdural hematoma	0	1	
Clavien-Dindo grade III			0.675
Anastomotic leak	6	1	
Anastomosis stricture	8	3	
Ulcus marginalis	7	5	
Internal hernia	3	0	
Clavien-Dindo grade IV			
None	0	0	
Clavien-Dindo grade V			
Death	1	0	1.000

Table 9. Comparison of postoperative outcomes. Values are expressed mean ± SD

	Group <55 years (n=417)	*Group ≥55 years (n=132)*	*P-value*
Weight loss at 6 months (Kg)	30.91±19.61	28.17±22.08	0.190
Weight loss at 12 months (Kg)	42.48±15.50	40.79±22.15	0.528
Weight loss at 24 months (Kg)	43.74±18.85	41.50±17.53	0.580
BMI at 6 months (Kg/m^2)	37.48±8.43	39.24±9.32	0.232
BMI at 12 months (Kg/m^2)	32.47±7.56	33.33±8.03	0.494
BMI at 24 months (Kg/m^2)	29.80±11.68	31.94±8.38	0.382
EWL at 6 months (%)	57.99±36.75	51.16±38.37	0.267
EWL at 12 months (%)	65.95±26.96	62.61±41.78	0.507
EWL at 24 months (%)	65.08±29.68	64.48±18.44	0.919
DM	105 (25.18%)	61 (46.21%)	<0.001
HT	179 (42.92%)	95 (71.97%)	<0.001

6.3 Study III. <5% (Group A) versus ≥5 - ≤10% (Group B) versus >10% (Group C) preoperative weight loss preceding LRYGB

The majority of patients (65.41%) lost over 5% of their weight preoperatively. Significant differences were found in operative time, conversion rates, and hospital stay among groups A and B or C (Table 10). Furthermore, a significant negative correlation was detected between the preoperative weight loss percentage and the length of hospital stay (r=-0.370, p<0.001). The intra-operative complications rate did not significantly differ among the three groups (Table 10). All intra-operative complications were managed without further sequel.

There were significant differences in overall early postoperative complication rates between the groups. Group A had a higher early morbidity rate (33.13%), p<0.05, Table 11) compared to groups B (19.25%) and C (11.89%).

The mean WL, BMI and mean EWL% at 6, 12 and 24 months are summarized in Table 12. The EWL% mean values were significantly higher at 12 months in group C (Table 12). However, no significant positive correlation between preoperative weight loss % and EWL % at one year (r=0.124, p=0.070) or two years (r=0.094, p=0.328) could be shown.

Table 10. Comparison of peri-operative parameters in three groups of patients according to the amount of preoperative weight loss.

	Group A (n=166)	*Group B (n=239)*	*Group C (n=143)*	*p-value*[a]	*p-value*[b]	*p-value*[c]
Operative time (min, mean ± SD)	104.43±36.40	80.08±23.07	76.99±23.23	<0.001	<0.001	0.210
Conversion	4 (2.41%)	0 (0%)	0 (0%)	0.028	0.009	1.000
Intra-operative complications	17 (10.24%)	14 (5.86%)	10 (6.99%)	0.128	0.420	0.668
Hospital stay (days, mean ± SD)	3.33±3.22	2.10±2.77	1.87±1.44	<0.001	<0.001	0.365

[a] Group A (<5% preoperative weight loss) versus Group B (>5% - <10% preoperative weight loss)
[b] Group A versus Group C (>10% preoperative weight loss)
[c] Group B versus Group C

Table 11. Postoperative complications < 30 days.

	Group A (n=166)	*Group B (n=239)*	*Group C (n=143)*	*p-value[a]*	*p-value[b]*	*p-value[c]*
Patients with complications	*44*	*40*	*15*	0.018	<0.001	0.099
Overall number of complications	55 (33.13%)	46 (19.25%)	17 (11.89%)	0.002	<0.001	0.065
Complications						
Wound infection	23	15	8	0.014	0.022	
Haemorrhage	7	17	5			
Anastomotic leak	4	4	1			
Anastomosis stricture	7	3	1			
Ulcus marginalis	7	3	0			
Pneumonia	2	2	0			
Others	5	2	2			

[a] Group A versus Group B
[b] Group A versus Group C
[c] *Group B versus Group C*

Table 12. Comparison of weight loss outcomes between three patient groups with different pre-operative weight loss percentages prior to laparoscopic gastric bypass surgery.

	Group A (n=166)	*Group B (n=239)*	*Group C (n=144)*	*p-value[a]*	*p-value[b]*	*p-value[c]*
Weight loss at 6 months (Kg, mean ± SD)	33.36±17.97	34.01±10.42	41.06±14.10	0.817	0.024	0.008
Weight loss at 12 months	38.22±16.77	41.49±14.07	51.87±20.61	0.166	<0.001	0.001
Weight loss at 24 months	41.86±17.86	40.88±16.18	52.40±22.93	0.795	0.054	0.048
BMI at 12 months (Kg/m^2, mean ± SD)	31.62±8.63	34.18±6.28	31.90±7.56	0.028	0.860	0.081
BMI at 24 months	30.42±10.56	30.95±12.22	28.55±9.79	0.829	0.561	0.533
EWL% at 6 months (mean ± SD)	53.17±18.35	54.12±14.79	62.48±15.19	0.962	0.313	0.010
EWL% at 12 months	63.06±19.61	63.61±20.52	72.69±21.72	0.946	0.053	0.015
EWL% 24 months	63.77±31.80	64.09±20.03	62.48±15.19	0.958	0.387	0.257

[a] Group A versus Group B
[b] Group A versus Group C
[c] Group B versus Group C

6.4 Study IV. Physical discomfort due to redundant skin

A 69% response rate was achieved (360 out of 524 patients). Altogether 320 persons (89% of responders) reported at least some problem with redundant skin after bariatric surgery. Only 11% did not have any complaint, 55% of these were female patients, their mean weight loss was 25.42±24.47 kg and ΔBMI 8.48±8.86, differing statistically from the rest of the study group ($p<0.01$).

Localization of the excess of skin is illustrated in Figure 15. Significantly more women than men reported inconvenience with the excess of skin ($p<0.001$). Women experienced the excess of skin in a higher number of body areas ($p<0.001$) and to a greater degree than men on abdomen, upper arm, rear/buttock and chest/breast ($p<0.001$).

Multivariate analysis showed a significant association between female sex (β=-13.56, 95% CI -16.81 - -10.32, p <.0001), amount of weight loss (β=0.21, 95% CI 0.12 - 0.29, p<.0001), and the value of ΔBMI (β=0.21, 95% CI 0.12 - 0.29, p<.0001) but not postoperative BMI (β=-0.12, 95% CI -3.05 - -0.07, p=0.139), nor younger age (β=-0.13, 95% CI -0.27 - 0.01, p <.0769), with discomfort due to redundant skin.

Patients with ΔBMI >20 kg/m^2 showed a significantly redundant skin discomfort compared to those with ΔBMI ≤5 and 5< ΔBMI ≤10 kg/m^2. Patients with a weight loss of >50 kg showed a significantly redundant skin discomfort compared to those with a weight loss of <20 kg. (Table 13).

There was no significant correlation or difference between physical skin discomfort and time delay since bariatric surgery or the type of bariatric procedure.

Finally, 9.2% of all patients revealed a high or very high overall daily impairment because of the excess of skin.

Of all the patients, only 28 were ≥55 years old, superobese, had undergone LRYGB and reported problems with redundant skin (total score 22.33±15.70), mostly at the abdomen (91%), upper arm (50%) and breast (32%, data unpublished).

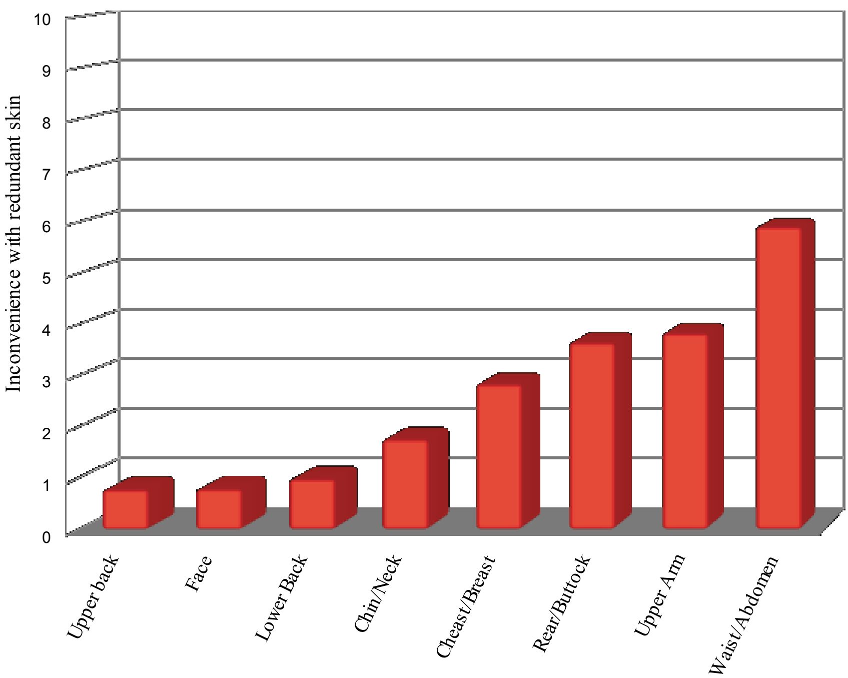

Figure 15. Redundant skin discomfort per body area.

Table 13. Patients' score of overall unpleasantness with excess of skin into different classes of ΔBMI and weight loss amount.

ΔBMI (kg/m^2)	Frequency (n) Percentage (%)	Mean (SD) Score	p-value*	Weight loss (Kg)	Frequency (n) Percentage (%)	Mean (SD) Score	p-value**
≤ 5	42 (11.67%)	11.32 (11.70)	<0.0001	< 20	70 (19.44%)	<0.0001	<0.001
> 5 and ≤ 10	91 (25.28%)	16.84 (15.59)	0.0009	≥ 20 and ≤ 30	87 (24.17%)	21.15 (15.83)	0.8148
> 10 and ≤ 15	120 (33.33%)	23.28 (15.69)	0.3785	> 30 and ≤ 40	77 (21.39%)	23.32 (16.51)	0.9995
> 15 and ≤ 20	67 (18.61%)	20.75 (13.84)	0.0976	> 40 and ≤ 50	63 (17.50%)	21.59 (14.79)	0.9151
> 20	40 (11.11%)	28.26 (16.37)		> 50	63 (17.50%)	23.89 (16.20)	

*Calculated as patients with a ΔBMI >20 kg/m^2 versus other classes. P-values were adjusted using Tukey-Kramer method.
**Calculated as patients with a weight loss > 50 Kg versus other classes.

6.5 Study V. Functional impairment due to surplus skin in successful postbariatric surgery patients (%EWL >50)

The majority of patients (92,8%) reported problems with redundant skin, especially on the abdomen, upper arms, and rear/buttocks. Significant positive correlation was found between redundant skin discomfort and female sex (rho=-0.125, p=0.019), amount of weight loss (rho=0.023, p=0.668) and EWL% (rho=0.015, p=0.777).

Patients with EWL% >50 showed a significantly surplus skin discomfort compared to patients with EWL% <50 (p<0.001, Table 14). Similarly, a significant difference in surplus skin discomfort between patients with postoperative BMI <32 and >32 kg/m^2 (p=0.011) was detected. No significant difference was found between patients with EWL% >50 and with postoperative BMI <32 (p=0.71, Table 15). Of all patients with EWL% >50, 66.7% also had BMI <32.

Of all the patients, only 18 were ≥55 years old, superobese, had undergone LRYGB, with EWL >50%, and they reported problems with redundant skin (total score 17.67±18.44), mostly at/on? the abdomen (78%), upper arm (46%) and breast (44%, data unpublished).

Table 14. Mean patients' degree of surplus skin discomfort after unsuccessful and successful bariatric surgery at follow-up by body region.

	EWL < 50% (n=131)	EWL > 50% (n=229)	Total per body region	*p-values*
Face	0.52±1.59	0.93±2.09	0.78±1.93	*0.02*
Chin/Neck	1.45±2.53	1.91±2.74	1.75±2.68	*0.03*
Upper Arm	2.70±3.52	4.42±3.94	3.82±3.89	*<0.01*
Upper Back	0.67±1.93	0.82±2.00	0.77±1.98	*0.13*
Chest/Breast	2.17±2.83	3.20±4.01	2.83±3.81	*0.02*
Waist/Abdomen	5.00±3.92	6.39±3.48	5.90±3.69	*<0.01*
Lower back	0.63±1.90	1.15±2.45	0.97±2.29	*0.02*
Rear/Buttock	2.38±3.48	4.33±3.90	3.64±3.87	*<0.01*
Total score	14.82±14.75	23.06±15.56	20.46±15.66	*<0.01*

Table 15. Functional impairment due to redundant skin in patients with %EWL <50 and BMI <32, <30 and <28.

	EWL % < 50 %	EWL % > 50%	*p-values*
Number of patients	131	229	
Skin Impairment Total Score	14.82±14.75	23.06±15.56	<0.01
	BMI >32 kg/m^2	BMI <32 kg/m^2	
Number of patients	201	159	
Skin Impairment Total Score	18.27±15.45	22.06±15.55	0.01
	EWL % > 50%	BMI <32 kg/m^2	
Number of patients	229	159	
Skin Impairment Total Score	23.06±15.56	22.49±15.95	0.64
	EWL % > 50%	BMI <30 kg/m^2	
Number of patients	229	159	
Skin Impairment Total Score	23.06±15.56	23.17±15.62	0.97
	EWL % > 50%	BMI <28 kg/m^2	
Number of patients	229	159	
Skin Impairment Total Score	23.06±15.56	24.07±16.10	0.71

6.6 Study VI. Desire and Expectations for Body-Contouring Surgery

The response rate was 69% (360 out of 524 patients).

The majority of patients desired body-contouring surgery, often in several areas, with high or very high desire in waist/abdomen (62.2%), upper arms (37.6%), chest/breast (28.3%) and rear/buttock (35.6%). Only 15.5% of patients did not desire any post-bariatric plastic surgery procedure. Mean desire values by body region are seen in Figure 16.

Multivariate analysis showed a significant association between female sex (β=-3.56, 95 % CI -4.52 - -2.61, p <.0001), younger age (β=0.09, 95 % CI -0.13 - -0.05, p <.0001), amount of weight loss (β=0.05, 95 % CI 0.02 - 0.070, p=0.0004), and ΔBMI (β=0.12, 95 % CI 0.05 - 0.20, p=0.0009), but not postoperative BMI (β=-0.12, 95% CI -3.05 - -0.07, p=0.139), and desire for body contouring.

When patients were stratified per age group, the desire for body contouring in all the different areas somehow decreased, while it remained constant in face and chin/neck areas with increasing age (Figure 17).

Patients over 50 years old showed a significantly decreased desire for body-contouring surgery only compared with patients <30 years old (Table 16). Indeed, a significant decrease in the wish for plastic surgery procedures was detected after 36 months from bariatric surgery, when patients were stratified per follow-up (Table 16).

Patients with ΔBMI >20 showed a significantly stronger overall desire for body contouring compared to those with ΔBMI ≤10. Patients with weight loss >50 kg showed a significantly stronger overall desire for body contouring compared to those with weight loss <20 kg (Table 17). There was no significant correlation or difference between desire and mean time since bariatric surgery or type of bariatric procedure.

Finally, of all patients, 36.4% had very high overall expectation for body-contouring surgery in terms of their appearance. There was a significant correlation between overall expectation for plastic surgery procedures and younger age (rho=-0.125, p=0.019), but not female sex (rho=-0.040, p=0.455), weight loss amount (rho=0.023, p=0.668) and ΔBMI (rho=0.015, p=0.777), follow-up (rho=0.06, p=0.205), nor desire (rho=0.077, p=0.151).

Of all the patients, only 18 were ≥55 years old, superobese, had undergone LRYGB, with EWL >50%, and they expressed a desire for body-contouring procedures (total score 5.33±5.25), mostly at the abdomen (82%), upper arm (52%) and breast (48%, data unpublished).

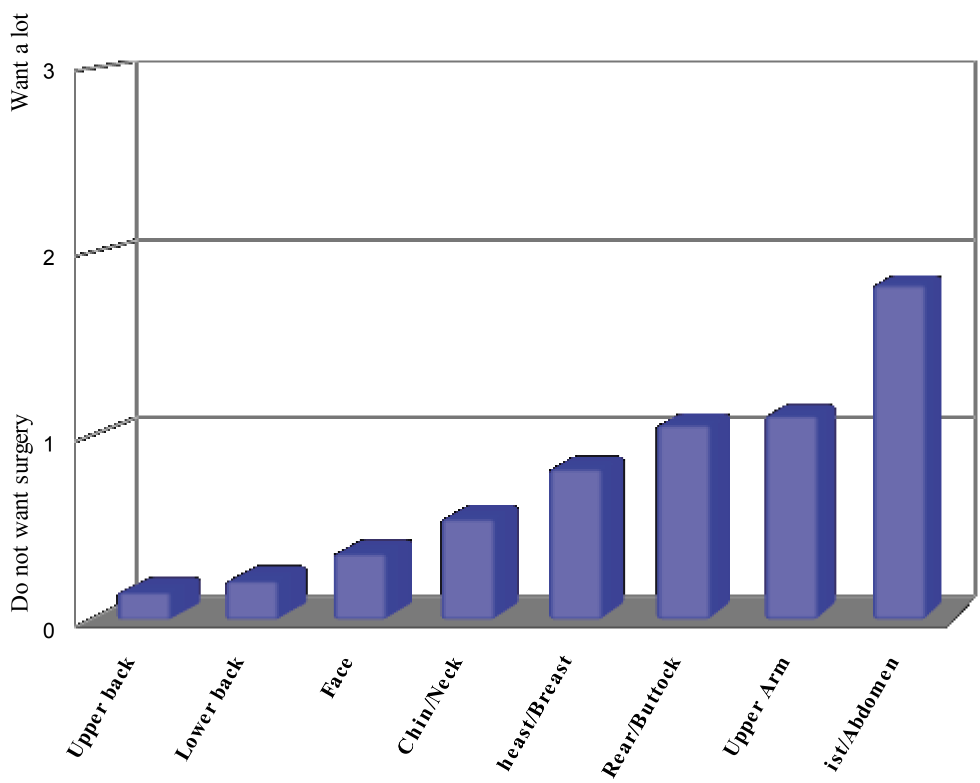

Figure 16. Mean desire for body-contouring surgery by body region.

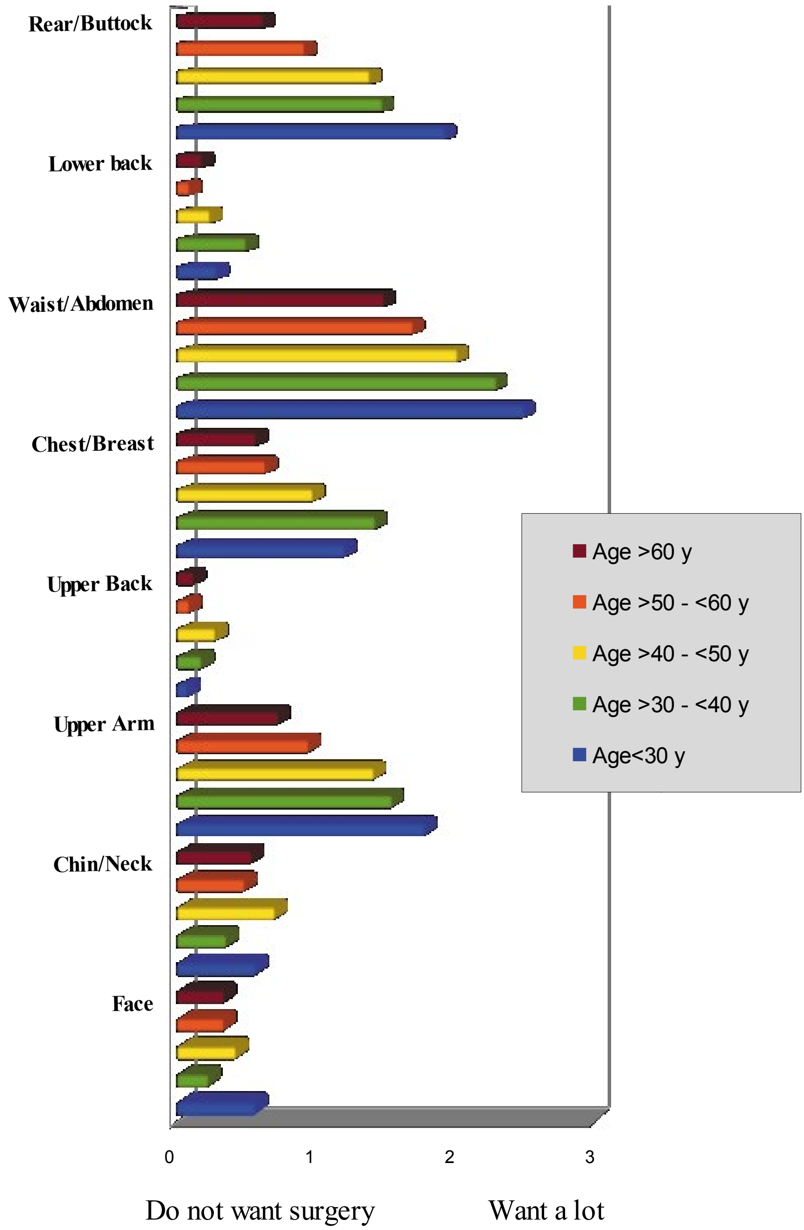

Figure 17. Desire for body-contouring surgery in different age groups per body area.

Table 16. Patients' desire for body contouring according to different classes of age and follow-up.

Age (years)	Frequency (n) Percentage (%)	Mean±SD (Range) Desire	*p-value*[a]	Follow-up (months)	Frequency (n) Percentage (%)	Mean±SD (Range) Desire	*p-value*[b]
≤ 30	14 (3.89%)	8.86±4.55 (0-16)		>12 and ≤ 18	78 (21.67%)	6.81±4.43 (0-18)	*0.007*
> 30 and ≤ 40	40 (11.11%)	8.00±4.21 (0-18)	*0.524*	>18 and ≤ 24	69 (19.17%)	5.32±4.62 (0-16)	*0.495*
> 40 and ≤ 50	95 (26.39%)	7.31±4.85 (0-17)	*0.263*	>24 and ≤ 36	139 (38.61%)	6.55±4.91 (0-18)	*0.012*
> 50 and ≤ 60	107 (29.72%)	5.11±4.12 (0-18)	*0.002*	>36	74 (20.55%)	4.71±4.26 (0-17)	
> 60	104 (28.89%)	4.49±4.48 (0-18)	*0.001*				

[a]Calculated as patients with an age ≤ 30 versus other classes. P-values were adjusted using Tukey-Kramer method.
[b]Calculated as patients with a follow-up > 36 months versus other classes.

Table 17. Desire for body-contouring surgery according to different classes of ΔMI and weight loss amount.

ΔBMI (kg/m^2)	Frequency (n) Percentage (%)	Mean±SD (Range) Desire	*p-value*[a]	Weight loss (Kg)	Frequency (n) Percentage (%)	Mean±SD (Range) Desire	*p-value*[b]
≤ 5	42 (11.67%)	4.41±4.52 (0-17)	*0.001*	< 20	70 (19.44%)	4.46±4.26 (0-17)	*0.007*
> 5 and ≤ 10	91 (25.28%)	4.98±4.28 (0-18)	*0.001*	≥ 20 and ≤ 30	87 (24.17%)	5.94±4.85 (0-18)	0.470
> 10 and ≤ 15	120 (33.33%)	6.54±4.70 (0-17)	0.133	> 30 and ≤ 40	77 (21.39%)	6.49±4.11 (0-18)	0.424
> 15 and ≤ 20	67 (18.61%)	6.22±4.57 (1-18)	0.094	> 40 and ≤ 50	63 (17.50%)	6.32±4.88 (2-18)	0.283
> 20	40 (11.11%)	8.48±4.34 (1-18)		> 50	63 (17.50%)	7.19±4.74 (2-18)	

[a]Calculated as patients with ΔBMI >20 kg/m2 versus other classes. P-values were adjusted using Tukey-Kramer method.
[b]Calculated as patients with weight loss > 50 Kg versus other classes.

7. DISCUSSION

7.1 LRYGB versus LAGB

There are several reasons to distinguish between morbid obesity (BMI >40 kg/m^2) and super-obesity BMI >50 kg/m^2), because the number of patients who fall into the superobese and super-superobese (BMI >60 kg/m^2) categories is growing (Søvik et al. 2010). Firstly, superobese patients more frequently have associated life-threatening comorbid conditions and, therefore, they have an elevated surgical risk (Baldieri et al. 2008). Secondly, superobese patients often fail to achieve satisfactory weight loss after purely restrictive operations (Victorzon et al. 2012, Topart et al. 2013). Thirdly, the heaviest patients need to lose more weight to achieve a valid reduction in their mortality risk (Christou et al. 2006).

Although evidence suggests that LAGB is not the most effective bariatric procedure concerning weight loss (Chakravarty et al. 2012), it is still performed around the world and especially in Australia, with a worldwide prevalence of 17.8% in 2011 (Buchwald et al. 2013, O'Brien et al. 2013). This may be related to the lower costs and early morbidity compared with LRYGB (Favretti et al. 2009), as a recent large study showed that the procedure with the lowest 30-day mortality rate is LAGB (0.02%, Benotti et al. 2014).

The LAGB operation is considered the least invasive method of all laparoscopic operations aiming at weight reduction and resolution of comorbidities. In addition, it is a totally reversible operation and easier to reverse compared to LRYGB. It may be associated with a shorter learning curve and a lower early postoperative complication rate compared to LRYGB (Chakravarty et al. 2012). On the other hand, LRYGB has been shown to be safe and effective in maintaining weight loss in the long term (Obeid et al. 2012).

Our retrospective analysis showed that in the perioperative and early postoperative phase (<30 days), Clavien–Dindo grade III complications (Dindo et al. 2004) were significantly higher in the LRYGB group, showing the potential risk associated with gastrointestinal tissue manipulation ($p = 0.01$, Table 5). Furthermore, the LRYGB group presented a significantly higher intraoperative complication rate ($p = 0.04$). Previous studies have shown early postoperative complication rates ranging from 0.8% to 12% in a LAGB series and from 5.5% to 30% in a LRYGB series (Nguyen et al. 2009). In our series, complication rates were 20.59% for LRYGB and 15.19% in LAGB (Table 5). The hospitalization time after both methods is low and even considered significantly lower in the LAGB group (Galvani et al. 2006). However, in our series of superobese patients we did not find any differences regarding the hospital stay ($p=0.80$).

Altogether, the early postoperative complication rate is low in both groups but seems to be slightly higher after LRYGB (Table 5). It is well known that late postoperative complications and failures are more common following LAGB operations compared to LRYGB operations (Angrisani et al. 2013, Victorzon & Tolonen2013), and may be even more so in superobese patients(Arapis et al. 2012). However, lower long-term complication rates and better outcomes in terms of WL after LRYGB are sometimes accompanied by serious life-threatening adverse events (Angrisani et al. 2013).

For the purposes of this study, we focused on relatively short-term outcomes. WL after LRYGB compared to that following LAGB was significantly greater at both 6- and 12-month follow-up. Similarly, BMI at 6 and 12 months was significantly lower after LRYGB. The EWL% mean values were significantly higher at 6 and 12 months in favour of the LRYGB group (Table 6). Previous long-term studies (>10 years) showed an EWL maintenance in the range of 33% to 60% after LAGB (O'Brien PE et al. 2013); therefore, the overall rate of revision might not be too different between LRYGB and LAGB, as the median rate for revisional procedures after LRYGB was 22%, with a range of 8% to 38% .

There is only one previous study comparing LAGB and LRYGB in superobese patients (Mognol et al. 2005) in which 290 patients with BMI >50 were studied: significant differences were found in the early postoperative period and hospital stay with more sustained weight loss at about two years in the LRYGB group. We did not find significantly different early morbidity between the groups except for the slightly higher incidence of intra-operative complications in the LRYGB group. In the present study, only 21 patients from the LRYGB group and 7 from the LAGB group were >55 years old with no significant differences in complications and outcomes (data unpublished).

7.2 LRYGB at elderly age

BMI and age have been described as strong predictors of risk for 30-day mortality in LRYGB patients, demonstrating even a continuous relationship between increasing BMI and increasing age with mortality risk (Livingston et al. 2002, Benotti et al. 2014). However, a large multicentre study showed that older age predicts prolonged length of hospital stay but not major events following bariatric surgery, although a non-statistically significant trend toward predicting mortality was detected (Dorman et al. 2012).

Recently, it has been shown that patients younger than 45 years lose a greater amount of excess BMI than older patients at 12 months (Contreras et al. 2013). In the same way, younger patients have a significantly greater and prolonged BMI decrease during the three-year-follow-up, particularly patients younger than 52 years of age (Scozzari et al. 2012). Our results did not show significant differences in weight loss, BMI and EWL% at 24-month follow-up, but comorbidity improvements were less sustained in the older patients (Table 8).

Older patients might lose less weight because of impaired metabolic capacity and greater presence of sarcopenia compared to younger patients. Energy requirements normally decrease with age with a lower lipolytic capacity, especially after sympathetic stimulation (Blaak 2000). This might explain the increased adipose tissue deposition in older subjects. These findings suggest that older obese women have a decreased capacity to supply energy through the mobilization of lipids from fat stores, and this could also induce a larger caloric intake after surgery. Total body energy expenditure begins to decline from the age of 40 years, and this age-dependent decrease is apparently due to a physical activity reduction (Ochner et al. 2013). The more sedentary lifestyle seems to be one reason for lower weight loss in patients older than 55 years (Lührmann et al. 2009, Frutos et al. 2006). Younger patients may have more active lifestyles with better exercise tolerance, and it is well known that successful long-term weight maintenance is associated with a physically active lifestyle (Elfhag et al. 2005). Indeed, because obesity is not only a medical condition but also a social disease, psychological and social aspects related to the patient's age may account for postoperative weight loss and maintenance, because these are associated with internal motivation and social support. Older obese people may be less inclined to maintain lower weights, because they are less denigrated than younger individuals (Elfhag et al. 2005).

The utility of bariatric surgery in the elderly population is often queried. Although outcomes might be worse than in younger patients (Trieu et al. 2007), previous studies have demonstrated significant excess weight loss, improvement in quality of life, reduction in daily medication use, and improvement in obesity-related comorbidity in the elderly population (O'Keefe et al. 2010, Wittgrove et al. 2009). Thus, also according to our results, elderly patients do benefit from bariatric surgery with acceptable rates of morbidity and mortality, which might justify taking a higher perioperative risk into account, and therefore bariatric surgery can have potential benefit in older patients, not only as prophylaxis but as partial treatment of comorbidities as well. Age alone should not be an absolute contraindication. Instead, indications should be carefully evaluated in the light of routine preoperative tests and discussed with the patient knowing that there is some risk and that the results may not be as good as they might expect.

7.3 Preoperative weight loss before LRYGB

Despite inconsistent evidence of its clinical benefits, the use of a preoperative weight loss regimen has nowadays been widely adopted in most bariatric surgery centres owing to its demonstrated effects on liver volume, abdominal and subcutaneous fat mass and comorbidity (Collins et al. 2011). These effects are supposed to improve intraoperative and postoperative outcomes. In contrast, an aggressive preoperative dietary intake restriction and a short period of preoperative fasting might be associated with postoperative complications due to malnutrition (Beckman et al. 2013).

It is commonly believed that preoperative weight loss results in technically easier bariatric procedures. This fact has been supported by several studies on LRYGB showing a significant reduction in the operative time between 9 and 37.40 minutes (Alami et al. 2007, Harnisch et al. 2008, Huerta et al. 2008). Similarly, we also found a significant and increasing reduction in the mean operative time between the different preoperative weight loss groups (-24.35 and -27.44 minutes, Table 10).

Interestingly, most of the studies did not find a significantly decreased overall operative complication rate after preoperative weight loss (Alami et al. 2007, Harnisch et al. 2008, Huerta et al. 2008). In particular, Still et al. observed that patients who lost 10% or more of their weight preoperatively were statistically less likely to have a long hospital stay (Still et al. 2007). Benotti et al. conducted a more detailed review on the same patients and confirmed this reduction in the frequency of surgical complications (Benotti et al. 2009). More recently, Van Nieuwenhove et al. showed similar results in a randomized multicentre study (Van Nieuwenhove et al. 2011).

In agreement with previous studies, we did not detect a significantly increased rate of intraoperative complications, while all four conversions to open surgery occurred in the group who lost <5% weight preoperatively (Table 10). Furthermore, the overall number of postoperative complications was significantly reduced in groups B and C (Table 11) with no substantial difference between these two groups.

The length of hospital stay has previously been assessed without showing a sustained difference between preoperative weight loss groups and non-preoperative weight loss groups (Harnisch et al. 2008, Huerta et al. 2008, Riess et al. 2008). In contrast, we noticed an important difference in the length of hospital stay with a mean difference of over one day between the groups, as well as a significant negative correlation (Table 10) resulting in a clear difference in costs.

The relation between pre- and postoperative changes in body weight is unclear, with results varying from a positive relationship (preoperative weight loss associated with greater postoperative weight loss) to a negative relationship (preoperative weight loss associated with less postoperative weight loss) and to no relationship (Ali et al. 2007, Alger-Mayer et al. 2008, Júnior et al. 2011). An improvement of EWL% in group C was noticed in our study during the early follow-up, but this improvement was not sustained at two years (Table 12). Similarly, no significant positive correlation between preoperative weight loss percentage and the amount of postoperative EWL% was detected.

There is no doubt that preoperative weight loss can be beneficial, but the current evidence on this topic cannot be used to deny or limit the access to bariatric surgery as this matter is still controversial. Not all patients will be able to achieve an appreciable preoperative weight loss, particularly superobese patients (BMI >50), patients with severe joint disease or insulin-dependent diabetes.

Although most studies recommend preoperative weight loss, the evidence is still not adequate. Based on our results, a preoperative weight loss of over 5% is recommendable as it may reduce operative time, hospital stay, and overall morbidity, with even some improvements in early weight loss outcomes. Among superobese patients, 79.41% had a weight loss of over 5% before LRYGB, while among elderly patients, only 48.24% achieved a preoperative weight loss of over 5% (data unpublished).

7.4 Physical discomfort due to surplus skin after MWL

Bariatric surgery has been increasing correspondingly with the increasing incidence of morbid obesity, and it delivers important improvements in comorbidity and quality of life (Sarwer et al. 2010), independently of the type of bariatric surgery procedures used. However, patients are normally not always prepared for the sequelae of the massive weight loss which might affect psychosocial life and body image (Coriddi et al. 2011, Singh et al. 2012, Peterhänsel et al. 2013).

Not only may the excess of skin contribute to medical conditions like skin infections but it can cause physical function impairments as well. Thus, surgery for these reasons must be considered to be rather reconstructive than cosmetic (Bruschi et al. 2009).

The majority of Finnish postbariatric surgery patients present physical discomfort, often in several body areas, particularly in the abdomen, upper arm, rear/buttock and chest/breast. We found a significant association between female sex, the amount of weight loss and difference in BMI with physical unpleasantness due to the surplus skin. Indeed, patients with a ΔBMI >20 kg/m^2 showed a significantly redundant skin discomfort compared to a ΔBMI ≤5 and 5< ΔBMI ≤10 kg/m^2 and patients with a weight loss >50 kg showed a significantly redundant skin discomfort compared to those with a weight loss <20 (Table 13). Similarly, patients who had successful bariatric surgery (EWL >50%) perceived a significant functional impairment due to redundant skin compared with the other unsuccessful postbariatric surgery patients (Table 15). Thus, these findings might be considered useful cut-off values.

Finnish guidelines consider elegiblity for postbariatric surgery patients to be a BMI cutoff of 32, but they do not take into account EWL% or ΔBMI values, nor our findings, as other countries guidelines. (Setälä et al. 2012, Soldin et al. 2014).

There are two previous similar studies (Bjöserud et al. 2011, Kitzinger et al. 2012) involving respectively 112 and 252 individuals completing a questionnaire, but they also included patients who previously had undergone at least some body-contouring procedure.

No correlation was found between surplus skin unpleasantness and age, time since operation or weight loss. Women were significantly more critical in their evaluations (Bjöserud et al. 2011, Kitzinger et al. 2012).

In our studies, we wanted to exclude patients who had undergone plastic surgery before in order to assess the qualification and quantification of the problem, and to compare that with objective measurements such as weight loss, BMI difference, and EWL%.

In general, elective body-contouring surgery should be delayed in this population until the weight has stabilized for a minimum of at least three months after a weight loss plateau is reached, generally 12 to 18 months after bariatric surgery (Gilbert et al. 2012). A stable weight prior to body- contouring surgery in postbariatric patients results in a significantly lower complication rate (van der Beek et al. 2011). Furthermore, current evidence supports the fact that a BMI < 30 kg/m^2 is associated with fewer complications in postbariatric plastic surgery (Coon et al. 2009).

Thus, a weight loss of over 20 kilograms, a ΔBMI >10 kg/m^2 and an EWL $>50\%$ might be considered for selecting patients for body-contouring surgery in a public healthcare insurance system.

7.5 Desire for body-contouring surgery

Although reductions in comorbidity after bariatric surgery are common, patients are often still very unhappy with their bodies (Gusenoff et al. 2008, Mitchell et al. 2008, Al-Hadithy et al. 2013). Thus, these patients are often highly motivated to seek and undergo body-contouring surgery.

Most postbariatric patients desire body contouring and a number of studies have shown that from 25% up to 54%, and as many as 84.5% of postbariatric patients desire body contouring, but only 21% to 25% actually undergo these procedures (Aldaqual et al. 2012, Al-Hadithy et al. 2013, Mitchell et al. 2008, Gusenoff et al. 2008, Kitzinger et al. 2012, Staalesen et al. 2013).

Our study, based on a Finnish population, showed that the majority of postbariatric surgery patients desire body-contouring procedures, often in several areas, especially in the abdomen, upper arm, chest/breast and rear/buttock. We found a significant association between female sex, younger age, amount of weight loss and ΔBMI with desire for body contouring.

In the previous studies, the desire for postbariatric body-contouring surgery has been focused mostly on the abdomen, upper arm and thighs, or breast areas in previous publications (Aldaqal et al. 2012, Mitchell et al. 2008, Kitzinger et al. 2012, Staalesen et al. 2013).

Steffen et al. (Steffen et al. 2012) did not find any correlation between desire and age, gender, follow-up or BMI change. Gusenoff et al. found an inverse correlation between desire and age, and years since gastric bypass (Gusenoff et al. 2008). They also showed a positive correlation between desire and female sex and marital status (divorced versus married individuals), which is in concordance with the findings in this study where a significant correlation between the desire for postbariatric surgery and younger age, female sex, amount of weight loss and difference in BMI could be seen. Interestingly, interest in a plastic surgery procedure did not decrease in the face and chin/neck areas with increasing age (Figure 17), while it decreased for the other areas especially in patients over 50 years (Table 16).

According to the previous literature on this topic, the desire for body-contouring surgery is mostly located in the abdomen, upper arm and thighs, or breast areas (Mitchell et al. 2008, Kitzinger et al. 2012 A, Aldaqal et al. 2012, Al-Hadithy et al. 2013). We confirm these findings (Figure 16) and suggest that also brachioplasty should be taken into consideration as a reconstructive procedure after massive weight loss, especially for Finnish patients.

Another interesting finding is that patients not only have a lower interest in body-contouring procedures with increasing age but also after three years' follow-up from primary bariatric surgery (Table 16).

We assumed that patients who lost more than 50 Kg and/or had a ΔBMI over 20 may have a stronger desire for body-contouring surgery. Therefore, patients were divided into groups on the basis of the amount of weight loss and ΔBMI and these were compared. Patients with a ΔBMI >20 showed a significantly stronger overall desire for body contouring compared to ΔBMI ≤5 and 5< ΔBMI ≤10. Patients with a weight loss >50 kg showed a significantly stronger overall desire for body contouring compared to weight loss <20. Therefore we indicated a relationships between desire for body contouring and the amount of weight loss and ΔBMI (Table 17).

Post-bariatric plastic surgery aims to treat both the functional and aesthetic problems caused by the surplus skin; increasing the patient's quality of life and self-esteem (Song et al. 2006). These patients generally have very high expectations for both aesthetic outcomes and improved quality of life (Kitzinger et al. 2012 B), and these findings were also supported in our study.

Many of the surgical procedures performed on massive weight loss patients are complex, labour-intensive and have a higher complication rate (Michaels et al. 2011), hence, body-contouring surgery cannot be delivered to all postbariatric patients. It has been demonstrated that postbariatric surgery patients undergoing body-contouring procedures present a higher risk for venous thromboembolism, hypothermia, baseline anemia, nutritional deficiencies (Naghshineh et al. 2010), and wound-healing impairment (Albino et al. 2009).

There are discrepancies between patients who receive and those who do not receive body-contouring surgery after massive weight loss, which might be attributed to their social status (Gusenoff et al. 2008). These procedures are not covered by third party payers in the USA but are usually restricted to abdominal problems, and only panniculectomies are covered. In addition, most of the patients cannot afford the cost of the surgery (Gurunluoglu 2009). Public insurance may offer and cover body-contouring procedures, but decisions have to be supported by appropriate indications (Sati et al. 2008). In a survey from the UK (Highton et al. 2012), only 22% of doctor respondents reported that their patients suffering from skin redundancy were able to access a plastic surgeon. Nevertheless, no clear criteria for referral were found and only a limited number of bariatric surgeons offer body contouring. A similar survey from the USA (Warner et al. 2009), where the healthcare system is insurance-based, showed that 87% of bariatric surgeons believe that deformities after massive weight loss are both functional and aesthetic. At present, there are no studies in which clear criteria for postbariatric body contouring have been addressed and insurance coverage might not be as beneficial as it may seem to both plastic surgeons and patients. Thus, there is definitely a need for developing guidelines, possibly evidence-based.

In South-East Scotland (Al-Hadithy et al. 2013), guidelines comprise: severe, intractable intertrigo beneath the skin fold and massive weight loss, a BMI ≤27; significant weight loss resulting in functional problems; lipodystrophy as an adjunct to reconstructive procedures. An attempt to define national guidelines has been recently proposed in the UK (Soldin et al. 2014) requiring a BMI <28 and/or EWL% >75% with weight stability for over 12 months. In Austria (Kitzinger et al. 2012 A), body-contouring surgery is covered by public insurance when there is a weight loss of more than 30% of the patient's original weight, if the patient concomitantly manifests other symptoms (i.e. spinal overload, eczema, infections, lymphedema, psychological problems). However, inclusion criteria are not always clear. In Finland, a scoring system for abdominoplasty indications has been developed. It is based on skin symptoms (i.e. recurrent cellulitis), weight stability (over 6 months) and a BMI less than 32, regardless of the weight loss methods, but panniculectomy can be performed for improving patients' functions (Setälä et al. 2012). In Sweden (Staalesen et al. 2012), abdominoplasty in postbariatric surgery patients is indicated if the panniculus hangs over 3 cm within a stable BMI <30 kg/m^2. Similarly, in Denmark, BMI has to be < 30 kg/m^2 and ΔBMI >15. In particular cases with a BMI over 30 kg/m^2, only panniculectomy is indicated (Post-bariatric surgery panel: the situation in Nordic countries. In: 34th Congress of the Scandinavian association of plastic surgeons. Helsinki, 13 - 16 June 2012).

According to our study, also other postbariatric surgery procedures are desired (i.e. brachioplasty) beside abdominoplasty/panniculectomy. We believe that total weight loss and BMI difference (ΔBMI) are more important criteria for assessing this kind of patient rather than merely BMI. In fact, we did not find a significant association between postoperative BMI at follow-up and desire for postbariatric plastic surgery procedures. Particularly, we showed that a weight loss over 20 kilograms and a ΔBMI >10 kg/m^2 might be considered for selecting patients for body-contouring surgery in a public healthcare insurance system.

The present study aimed to explore the desire for body-contouring surgery after bariatric surgery for morbid obesity in a single bariatric surgery institution, in patients with a stable weight for at least one year, and who had not undergone any body-contouring procedures.

7.6 Limitations of the studies

Studies I, II and III have several limitations including their retrospective and non-randomised nature, as well as the preoperative patients' different demographics, such as the different incidence of comorbid conditions like hypertension and diabetes, favouring the younger patients. Although a cut-off at 55 years of age might seem arbitrary, we analysed the age continuously with the other variables but were unable to find a significant cut-off age above which there is an increased risk (Lynch et al. 2012). In the bariatric surgery literature, the age of 55 has been commonly used to define the older age, so it was considered an appropriate cut-off for the purposes of this study, although this is low compared to the non-bariatric surgery literature (Lynch et al. 2012, Contreras et al. 2013).

Indeed, the group which had the greatest pre-operative weight loss percentage, also had the greatest weight loss at one year follow-up after LRYGB. This fact might magnify the post-operative differences as opposed to BMI-matched groups differing only in preoperative weight loss, thus conferring a potential bias to this study. There is also a lack of standardization of the preoperative weight loss method and follow-up of the patients during this period.

It is also difficult to evaluate the possible impact of the learning curve on the results, as 11 of the super-obese and 17 elderly patients undergoing LRYGB were operated during our learning curve period for this procedure (Victorzon et al. 2012).

Another potential bias may come from the proportion of patients lost to follow-up, which is known to create a particular challenge in assessing bariatric surgical outcomes, as it is likely that the bariatric surgery patients who are not doing well are the most hesitant to return for follow-up.

Finally, the results of this study should be interpreted with caution as it is not a randomised study, and these results are relatively short-term. More long-term results on this topic are needed.

Although the findings presented in studies IV, V and VI are interesting, there are several limitations including the subjective nature and non-validation of the questionnaire, as well as the underestimation of physical symptoms and the low response frequency (69%), which may reflect a self-report bias. Altogether 164 persons did not respond to the questionnaire and, although there were no statistically significant demographic differences between responders and non-responders, we do not know whether their answers would have affected the results of this study. It is possible that patients with physical discomfort due to their redundant skin were more likely to take part in this study.

Furthermore, the results may have been affected by the fact that female patients usually have a lower threshold for unacceptable appearance than men. Previous pregnancies may also play a role. Nevertheless, we were not able to consider the possible impact of patients' comorbidities on the results due to a lack of data.

These proposed metrics give no insight as to whether patients who meet these criteria for surgical indication would actually benefit from it; and it does not take into account medical issues and co-morbidities.

7.7 Future Directions

In the last decade, the robotic platform has been used in different surgical fields. The growth of bariatric surgery has resulted in varying types of procedures with increasing complexity. Robotic digital platforms are now employed in bariatric surgery to address this increasing complexity in the high-risk obese patient population with difficult anatomy (Wilson et al. 2013).

According to the previous studies, robotic procedures are associated with better ergonomics for the surgeon, better visualization of the anatomy, easier fine dissection (i.e., lymphadenectomy) when required, and higher costs (Toro et al. 2014).

Particularly, in bariatric surgery, the clinical advantages have not been well documented yet; however, it seems robotics shortens the learning curve of Roux-en-Y gastric bypass (RYGB). Concerning other bariatric procedures, both robotic SG and LSG have shown excellent and similar post-operative clinical outcomes, but the much higher costs of purchasing and maintaining the robotic system still preclude the routine use of robotic SG (Schraibman et al. 2014).

The use of robots in selected cases may have specific advantages and may overcome the limitations of laparoscopic surgery. Further research is needed in this field, especially large and well-designed randomized clinical trials, to elucidate more accurate conclusions (Toro et al. 2014).

At the same time, the number of bariatric surgery procedures performed yearly is increasing continuously, with a trend of +69% from 2008 to 2011 (Buchwald et al. 2011). There has been a reduction in LAGB procedures and a tremendous increase in SG surgeries from only 7% of bariatric surgery in 2008 to 27.8% in 2011 (Buchwald 2011). Paralleling these trends, also the BMI values and the patients' age are decreasing, resulting in an expansion of indications for bariatric surgery (Busetto et al. 2014)

Not only the numbers of adults, but also the numbers of severely obese teenagers are increasing and many of these people will suffer multiple lifestyle impacting co-morbidities (Freedman et al. 2007). It has been estimated that 84% of obese children will become obese adults. The role of bariatric surgery for these patients is already gaining importance (Fitzgerald et al. 2014).

Subsequently, there is a continuously increasing demand for body-contouring surgery. However, only a minority undergo these procedures (Kitzinger et al. 2012). Even adolescent postbariatric patients have shown problems concerning unattractive body and the developing of excess of skin in upper arms and thighs (Staalesen et al. 2014).

There is a lack of knowledge of the medical necessity criteria for these procedures in the light of funding in insurance and public health systems. The average estimated cost of postbariatric surgery body contouring is relatively high, due to the multiple procedures and it increases in case of complications (Poyatos et al. 2014). Therefore, it is very important to address coverage guidelines with an effort to unify them.

Healthcare professionals must address the current imbalance between requests for and the performance of body-contouring surgery in adults and also in adolescents.

8. CONCLUSIONS

On the basis of this study the following conclusions may be drawn:

1. There seems to be no significant difference in early complications between LRYGB and LAGB operations. Weight Loss and EWL% at 6 and 12 months are significantly better after LRYGB.

2. LRYGB for patients ≥55 years achieves outcome and complication rates comparable to those of the younger population. Patients should not be denied bariatric surgery because of age alone. Elderly patients do not achieve improvement of comorbidities to the same extent as younger patients do.

3. A preoperative weight loss of >5% prior to LRYGB may reduce operative time, hospital stay and overall morbidity.

4. Weight loss after bariatric surgery reduces the medical risks of obesity but psychosocial and functional problems often remain due to the surplus skin. A ΔBMI ≥ 10 kg/m^2 and weight loss >20 kg, not BMI alone, are significantly correlated to physical discomfort due to redundant skin.

5. Successfully treated bariatric surgery patients (EWL% >50) showed significant impairment due to surplus skin.

6. Most patients desire body-contouring surgery after bariatric surgery independently of BMI. Patients with a ΔBMI >10 kg/m^2 and weight loss ≥20 kg have a stronger desire for body- contouring plastic surgery.

9. ACKNOWLEDGEMENTS

These studies were carried out at the Department of Surgery, in Vaasa Central Hospital and at the Department of Plastic and General Surgery, in Turku University Hospital during the years 2010-2014.

I wish to express my deepest gratitude to my supervisor, Professor Mikael Victorzon, Head of the Department of Surgery, who gave me the great opportunity of working with him, teaching me the basis of surgery and research at the early stage of my career. The initial idea of this project came from him through his clinical material, and I wish to thank him for his enthusiastic guidance and expert advice during all phases of these studies.

My warmest thanks go to my supervisor Adjunct Professor Erkki Suominen for encouraging me in this research, mentoring and teaching me plastic surgery. His guidance helped me to understand the importance of scientific critical thinking. His knowledge and enthusiasm for plastic surgery have inspired me through this work.

I am truly thankful to Adjunct Professor Virve Koljonen and Adjunct Professor Markku Luostarinen, the official reviewers of this thesis for their careful evaluation and constructive criticism.

I am grateful to Doctor Pekka Tolonen for his contribution to this study and his guidance during my gastrointestinal surgery training.

I would also like to thank Doctor Ilkka Koskivuo, the Head of Department of Plastic and General Surgery, for participating to one study, allowing me some free time for research and overseeing the progress of this doctoral thesis. I am also thankful for his guidance during my training in plastic surgery.

My thanks also goes to my teacher colleagues at the Department of Plastic and General Surgery, Doctors Tarja Niemi, Esko Veräjänkorva, Tiina Viitanen, Anne Saarikko, my colleagues at the Breast Cancer Unit and all the residents of the Department for their positive attitude towards my scientific work.

I warmly thank Doctor Nina Bruk for optimizing my work shift in order to improve my research efficiency and for her invaluable help in organizing all practical issues beyond the thesis.

I want to express my gratitude to all surgeons colleagues from Vaasa Central Hospital during my stay in the years 2007-2010 for their teaching and support at work. Especially I wish to thank secretary Virpi Nyberg-Paavola.

I am much indebted to Adjunct Professor Hannu Kuokkanen who permitted me to spend a period at the Department of Plastic Surgery of Helsinki University Hospital and, later on, at Tampere University Hospital. I do remember his patience and encouragement when I finished the Medical School and, more recently, his wise suggestions during my training.

I wish to express my gratitude to Professor Erkki Tukiainen, Adjunct Professor Sinikka Suominen and the other colleagues from the Department of Plastic Surgery of Helsinki University Hospital, where I had an invaluable experience first as medical student in 2005 and then as plastic surgery resident in 2013-2014.

I am grateful to Teija Stormi, from the Department of Biostatistics of University of Turku for the statistical analysis of two studies.

I want to thank Jacqueline Välimäki for the linguistic revision of this thesis.

Last but not least, I sincerely thank my dear friend Adjunct Professor Fausto Biancari for encouraging me during my initial Finnish experience and introducing me the world of clinical research.

I shall always be grateful to my dear parents, Bianca and Luigi, for making it possible for me to do whatever I wanted, and for having never-ending faith in me.

Finally, my sincere gratitude goes to the one who has been at my side, walking through this time of my life.

This study was financially supported by the University of Turku, the EVO Foundation of the Department of Surgery, Vaasa Central Hospital and of the Department of Plastic and General Surgery, Turku University Hospital; and Chirurgi Plastici Fenniae Ry.

Turku, December 2014

Salvatore Giordano

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