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ORIGINAL ARTICLE

Does extreme weight loss after bariatric surgery alter spinopelvic parameters and ameliorate back pain? A retrospective case study

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ABSTRACT

Objectives: The aim of this study was to evaluate the effect of extreme weight loss on low back pain and spinopelvic parameters.

Patients and methods: A total of 45 patients (11 males, 34 females; mean age: 40.2±9.4 years; range, 18 to 57 years) who had bariatric surgery between January 2018 and December 2021 were retrospectively analyzed. Radiological spinopelvic parameters including lumbar lordosis (LL), pelvic incidence (PI), spinopelvic harmony (when PI is within LL±10°), pelvic tilt (PT) and sacral slope (SS) were evaluated pre- and postoperatively. Clinical outcomes were assessed using the Visual Analog Scale-Back Pain (VAS-BP) and Oswestry Disability Index (ODI).

Results: The mean BMI loss at the end of the first year after surgery was 28.1±6.7% (range, 21 to 36%). The mean PI was 55.75°±12.47° preoperatively and 53.64°±11.86° at one year and the difference was -3.10°±5.25 (p=0.02), 1.10°±4.95° for PT (p=0.46), -2,70°±3.50° for SS (p<0.001), and 3.1±6.55 for LL (p<0.001). At one year, spinopelvic harmony remained unchanged in 31 patients, nine patients regained harmony, and was lost in five patients who had previously. No significant correlation between alterations in spinopelvic alignment and ODI scores was shown (p<0.05). The mean VAS-BP score was 40±30 mm preoperatively, and 20±3.5 mm postoperatively, indicating a difference of -39±29.5 (p<0.001). The mean ODI was 34.71±20.87 preoperatively, and 16±24 postoperatively, indicating a difference of -15±13 (p<0.001). Subgroup analyses showed that the change in SS was more pronounced with regard to PT change, particularly in young and female patients with >10 kg/m^2 reduction in BMI (p<0.001).

Conclusion: Weight loss after bariatric surgery improves lower back pain leading to changes in PT without affecting SS and altering PI.

Keywords: Bariatric surgery, extreme, harmony, obesity, pelvic incidence, weight-loss.

Low back pain and obesity represent two predominant sources of economic strain on countries, with their coexistence being an undeniable reality. Obesity encompasses a spectrum of associated conditions such as hypertension, diabetes, non-alcoholic fatty liver disease, osteoarthritis, and cardiovascular disease. Furthermore, it is implicated in joint pain, organ damage, depression, and sleep disorders, with extensive research elucidating its systemic effects.[1]

While numerous studies have elucidated the metabolic repercussions of increased adipose tissue mass on musculoskeletal pain, the mechanical

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implications have sparked debate. Nonetheless, the occurrence of joint pain beyond weight-bearing regions has diverted attention from purely mechanical explanations.[2] A meta-analysis by Walsh et al.[3] showed that tumor necrosis factor-alpha (TNF-α), an inflammatory cytokine overproduced in response to excess dietary fat, contributed to musculoskeletal pain. Another plausible pathway linking obesity and musculoskeletal pain involves heightened leptin secretion from subcutaneous adipose tissue, known for its proinflammatory properties. Previous research has associated increased body fat mass with widespread low back, knee, and foot pain, implicating systemic inflammation.

Despite detailed investigations into the adverse metabolic effects of increased adipose tissue on joints, eccentric loading on the axial skeleton may underlie low back and hip pain, particularly in cases of central obesity. Evidence supporting this theory includes observations of pain resolution following weight loss surgery, indicating the role of obesity as a predisposing factor.[4-8] Various medical and surgical weight loss methods aim to mitigate musculoskeletal pain and counteract detrimental effects of obesity on other organs, particularly among individuals with comorbidities or a body mass index (BMI) exceeding 35 kg/m^2.[9]

Bariatric surgery, the primary approach for severe obesity (particularly Class III patients), is deemed successful, if it achieves a weight loss of 20 to 30% of initial weight or reduces BMI below 35 kg/m^2 within the first year of surgery.[10] A systematic review including 2,526 patients from nine studies undergoing bariatric surgery for obesity revealed substantial weight loss and improved functional status, indicating a correlation with reduced low back pain.[11]

Despite extensive research on metabolic effects, comprehensive pre- and postoperative assessments of spinopelvic dynamics in patients with obesity remain scarce. In the present study, we hypothesized that bariatric surgery would improve the quality of life of patients by alleviating low back pain and induce alterations in spinopelvic dynamics. We, therefore, aimed to assess the impact of bariatric surgery on spinopelvic parameter alterations and health outcomes following weight reduction surgery.

PATIENTS AND METHODS

Study design and study population

This retrospective case study was conducted at University of Health Sciences, Atatürk Sanatoryum Training and Research Hospital, Department of Orthopedics and Traumatology between January 2018 and December 2021. The structural and functional effects of rapid and significant weight loss after bariatric surgery on the spinopelvic junction were recorded through the retrospective analysis of prospectively collected data. During the study period, a total of 113 Class III extremely obese patients with a BMI of >40 kg/m^2 who underwent bariatric surgery in our center were identified. Of these, 98 patients also had preoperative low back pain complaints without radiculopathy or radiculitis symptoms. A total of 53 patients who did not meet eligibility criteria were excluded (n=7 who could not achieve at least 5 kg/m^2 BMI reduction at the end of the first year postoperatively, n=15 who could not attend follow-up examinations as they lived abroad, n=13 with radiological images of insufficient quality for measurement, n=7 who developed postoperative complications, and n=11 with missing preoperative data). Finally, a total of 45 patients (11 males, 34 females; mean age: 40.2±9.4 years; range, 18 to 57 years) were included in the study.

Radiological evaluation

With the patient in an upright position, with both cervical vertebrae and the pelvis visible, all the images were obtained using the Discovery XR 656 system (GE Healthcare Corp., Chicago, IL, USA). To prevent potential errors during both the acquisition and evaluation of lateral scoliosis radiographs, strict adherence to guidelines was maintained. During the imaging, the patient maintained a horizontal gaze with elbows flexed and hands placed over the clavicles. The radiation source was positioned 183 cm away from the patient, and the rays were focused perpendicularly, ensuring proper alignment. Pelvic incidence (PI), pelvic tilt (PT), lumbar lordosis (LL), and sacral slope (SS) were measured using Surgimap software (Surgimap; Nemaris Inc., New York, USA). The PI, PT, and SS are arithmetic sums, where PT is the angle between the midpoint of the femoral heads and the midpoint of the first sacral endplate, and the vertical imaginary line. The SS indicates the inclination of the first sacral endplate relative to the ground. The standing lateral pelvis view was used to measure the pelvic parameters. Lumbar lordosis was measured from lateral scoliosis X-rays. Roussouly subgroups were selected from the spinopelvic parameters and radiograms.[12] To determine spinopelvic harmony, patients were evaluated using the equation of 'PI=LL±10°. Due to the difficulty in identifying anatomic landmarks caused by the presence of a thick fat mass due to obesity, a spine surgeon with a minimum of 10 years of experience and the most senior resident, after receiving tutorials, measured and recorded sagittal parameters twice, with at least a three-week interval between each measurement. Interclass coefficients (ICCs) were calculated and noted between measurements.

Clinical evaluation

The preoperative standing pelvis radiograms and lateral scoliosis X-rays were retrieved and the Visual Analog Scale-Back Pain (VAS-BP) and Oswestry Disability Index (ODI) scores. After obtaining preoperative data from patients, functional and radiological evaluations were conducted at postoperative one, three, six, and 12 months. During follow-up, the VAS-BP, ODI and lateral scoliosis X-rays were repeated.

For subgroup analysis, sex, age (≤40 or >40 years), and a BMI reduction of 5 to 10 kg/m^2 or >10 kg/m^2 were used.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 28.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. Conformity of the data to normal distribution was assessed with the Shapiro-Wilk test. To analyze pre- and postoperative measurements, the dependent samples t-test was used for normally distributed data and the Wilcoxon test for non-normally distributed data. The classic ratio test was used to determine spinopelvic harmony. The ICC values were used for interobserver reliability. A *p* value of <0.05 was considered statistically significant.

TABLE I
The comparison of radiological parameters

Parameter	Mean±SD	*p*
PI		0.02
Preoperative	55.75±12.47	
Postoperative	53.64±11.86	
PT		0.46
Preoperative	18.05±8.43	
Postoperative	18.24±6.81	
SS		0.001
Preoperative	35.51±14.85	
Postoperative	34.13±9.97	
LL		0.001
Preoperative	58.02±11.62	
Postoperative	61.76±9.99	

PI: Pelvic incidence; PT: Pelvic tilt; SS: Sacral slope; LL: Lumbar lordosis.

RESULTS

There was no significant difference in the demographic characteristics of the patients (p>0.05). The mean BMI loss at the end of the first year after surgery was 28.1±6.7% (range, 21 to 36%). For both pre- and postoperative measurements, PT, PI, SS, LL values and determination of Roussouly subgroups showed high values of interobserver correlation and Cohen's kappa coefficients, and were deemed excellent (r=0.93-0.97; p<0.001).

The data of the pre- and postoperative radiological measurements of the patients are shown in Table I. Preoperatively, there was no significant difference in PT between the pre- and postoperative measurements (p=0.46), while SS decreased significantly (p<0.001) and LL increased significantly (p<0.001) postoperatively. During the initial year of follow-up, spinopelvic alignment remained unaltered in a collective of 31 patients, was restored in nine patients, and deteriorated in five patients. Nonetheless, no significant correlation between alterations in spinopelvic alignment and ODI scores was observed (p<0.05).

The mean PI was 55.75°±12.47° preoperatively, 53.64°±11.86° at the final follow-up and the difference between the two measurements was 3.10°±5.25° (p=0.02). In the correlation analyses, first, the correlation between PI change and preoperative PT difference was investigated, and there was seen to be a significant, linear, negative correlation between the decrease in the final follow-up PI and preoperative PT (Figure 1). A positive and significant correlation was found between the final follow-up changes in PI

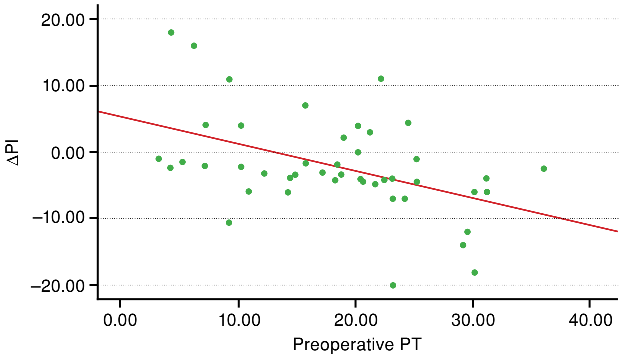

FIGURE 1. The correlation between preoperative PT and change in PI.
PI: Pelvic incidence; PT: Pelvic tilt.

and changes in PT, LL, and SS (Figure 2; Table II). The change in arithmetic PI was more influenced by an increase in PT, and the increase in SS did not affect PI as strongly as the change in PT (Table III).

The mean VAS-BP was 40±30 mm preoperatively, 20±3.5 mm at the final follow-up and the difference between the two measurements was –39±29.5 (p<0.001) (Figure 3). The mean ODI score was 34.71±20.87 preoperatively, 16±24 at the final follow-up, indicating a difference of –15±13 (p<0.001) (Figure 4).

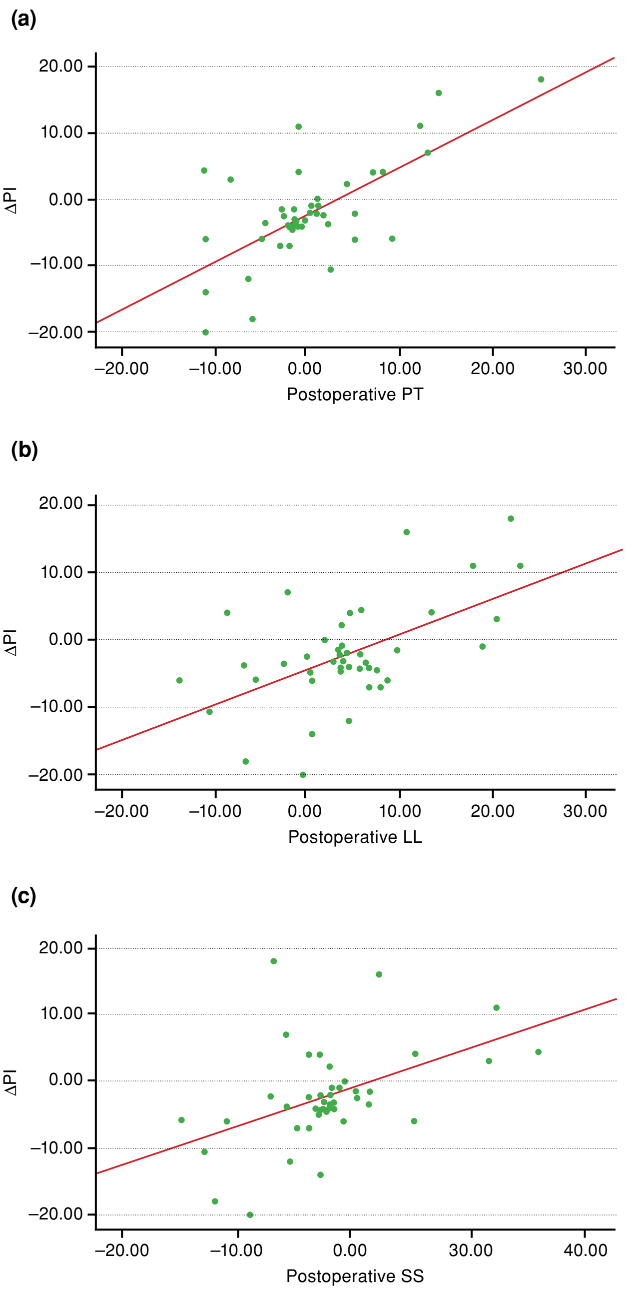

FIGURE 2. The correlation between postoperative **(a)** PT **(b)** LL **(c)** SS with change in postoperative PI.

PI: Pelvic incidence; PT: Pelvic tilt; LL: Lumbar lordosis; SS: Sacral slope.

Subgroup analyses for the preoperative versus final follow-up radiological and functional results are summarized in Table III. In all patients with weight loss, there was a significant change in SS, and in those with >10 kg weight loss, there was a significant change in PI. After bariatric surgery, a BMI difference of >10 kg/m^2, particularly in young female patients, was observed to lead to a significant decrease in SS without a significant change in PT, and an increase in LL. There was a statistically significant decrease in PI in this patient group. No statistically significant difference was found between males and females in terms of ODI scores.

DISCUSSION

The main finding of this study was that, contrary to common belief, PI was not a constant parameter, and particularly in young females when there was a >10 kg/m^2 decrease in BMI after bariatric surgery, as SS decreased, leading to a reduction in PI and PT remained unchanged, but LL increased.[13] Likewise, notable enhancements were noted in both ODI and VAS-BP scores at the conclusion of the initial year among all patients within this particular case series, characterized by a marked reduction in BMI, with ODI's minimally clinically important difference (MCID) value being 10 points.

Although there are many studies in the literature on the effect of obesity on low back pain, there are hardly any studies examining its relationship with pelvic parameters. The most original study demonstrating that the PI is a dynamic parameter rather than fixed is the study by Schroeder et al.[14] in which pelvic parameters were evaluated

TABLE II
The correlation of PI changes with other variables

	ΔPI	
Parameters	r	*p*
Δ PT	0.678	<0.001*
Δ BMI	0.165	0.280
Δ SS	0.459	0.001*
Δ LL	0.563	<0.001*
Δ VAS	–0.124	0.417
Δ ODI	0.102	0.507

PI: Pelvic incidence; PT: Pelvic tilt; BMI: Body mass index; SS: Sacral slope; LL: Lumbar lordosis; VAS: Visual Analog Scale; Δ: The change between preoperative and postoperative values; ODI: Oswestry disability index.

TABLE III
Subgroup analysis of significance

Subgroup	PI	PT	SS	LL	VAS-BP	ODI	BMI
BMI							
Reduction <10	0.32	0.35	**0.01**	0.27	**<0.001**	**0.01**	
Reduction >10	**0.02**	0.22	**0.03**	**<0.001**	**<0.001**	**<0.001**	
Age							
≤40	0.50	0.24	**<0.001**	0.30	**<0.001**	**<0.001**	**<0.001**
>40	**0.02**	0.08	0.09	**<0.001**	**<0.01**	**<0.001**	**<0.001**
Sex							
Male	0.09	0.48	0.12	**0.02**	**<0.001**	0.49	**<0.001**
Female	0.09	0.89	**<0.001**	**0.02**	**<0.001**	**<0.001**	**<0.001**

PI: Pelvic incidence; PT: Pelvic tilt; SS: Sacral slope; LL: Lumbar lordosis; VAS-BP: Visual Analog Scale-Back Pain; ODI: Oswestry disability index; BMI: Body mass index.

on lumbar flexion and extension radiographs, and PI was reported to be approximately 1 degree less in extension than in flexion due to changes in SS rather than PT. In this study of 72 patients, the PI was higher in flexion than in extension in 60% of the patients when the standard measurement error margin was taken into account. In the same sample group, PI changes exceeding the margin of error were observed in 38% of obese patients, although this rate was reported as 8.5% in non-obese patients. In contrast to the aforementioned study, which is controversial due to the cross-sectional design and the very wide confidence intervals reported for the effects of obesity, it was attempted to more clearly demonstrate the cause-effect relationship in the patient group of the current study, as obesity was eliminated after the surgical method.

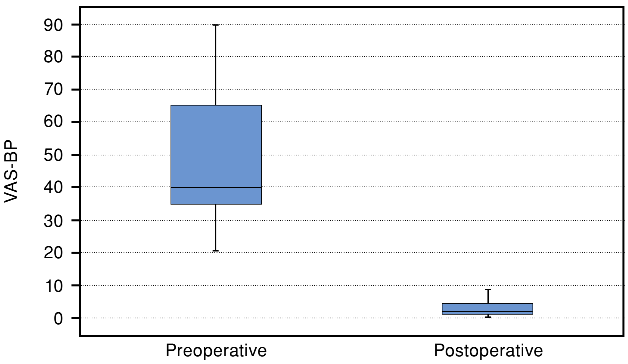

FIGURE 3. Comparison of preoperative and postoperative VAS-BP.
VAS-BP: Visual Analogue Scale-Back Pain.

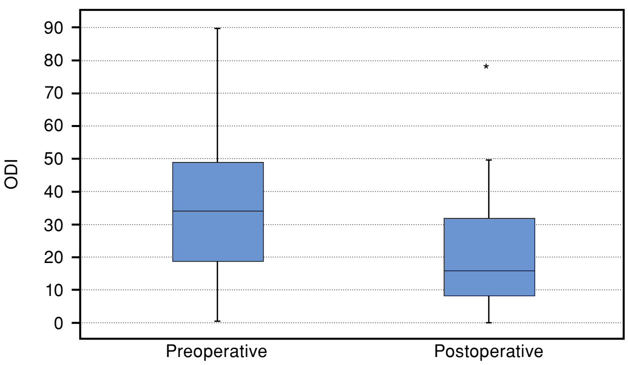

FIGURE 4. Comparison of preoperative and postoperative ODI scores.
ODI: Oswestry disability index.

Many studies and meta-analyses have provided important and high-evidence information on the alleviation of axial skeletal pain after bariatric surgery.[4,7,15] Although it has been shown in this and other studies that severe weight loss will relieve low back pain, the reason has not been fully elucidated yet. Roussouly and Pinheiro-Franco[12] evaluated the adaptation of the spine to pathological changes, and suggested that excessive mechanical stress would accelerate the degenerative process of the spine, which would naturally age and become more hypolordotic over time. The basic theories explaining this are that the contact force, which is defined as the resultant force of the system created by gravity and abdominal pressure from the front and the dense paraspinal muscle mass from the posterior, mainly targets the discs. From a mechanical point of view, this resultant decrease in strength seems to lead to a decrease in paraspinal muscle metabolism and consequently a decrease in energy expenditure, a decrease in contact stresses on the posterior spinal structures, and ultimately an improvement in pain and disability. In this respect, biomechanical studies will be more enlightening.

Although the general opinion is that PI is a constant parameter, some studies in recent years have suggested that it is not.[16-19] The common opinion of all these studies is that the degeneration in the sacroiliac joint cannot balance the rotational forces acting on this joint, leading to changes in the PI. The current study differs from that of Hu et al.[19] in that extreme weight loss resulted in a decrease in SS without significant change in PT and thus resulted in a decrease in PI. In the aforementioned retrospective case series, it was shown that after spinopelvic fixation using an S2 alar iliac screw, PI decreased in half of the patients, and the decrease in PI was clearer in cases where spinopelvic harmony was more impaired preoperatively and PT was lower postoperatively. As shown in the current study, this complex relationship is similar to the findings of Lee et al.,[20] with changes in SS where pelvic fixation was not applied but posterior spinal fusion was performed, although Lee et al.[20] reported an increase in PI in their cases. This difference can be explained by surgical methods such as cantilever forcing the sacroiliac joint to rotate, the decrease in PI without significant change in harmony after bariatric surgery seems to depend on the lower lumbar region mechanically relaxing and taking its natural shape.

The correlation between back pain and functional outcomes subsequent to bariatric surgery has garnered considerable attention among both scholars and practitioners. Numerous investigations have underscored a notable amelioration in the severity of back pain and enhancement in functionality following surgical intervention, a trend closely linked to significant weight reduction.[17-19] Bariatric surgery not only mitigates the mechanical strain on the spine consequent to diminished adipose tissue, but also addresses the systemic inflammation characteristic of obesity, a factor contributing to musculoskeletal discomfort.[3] Furthermore, the observed enhancement in functional outcomes, exemplified by augmented mobility and diminished disability, is ascribed to the improved overall health status and heightened quality of life post-weight loss surgery. Nonetheless, a comprehensive exploration of the precise mechanisms facilitating the mitigation of back pain and the enhancement of functional outcomes subsequent to bariatric surgery is imperative to refine patient care and treatment modalities.

Nonetheless, there are some limitations to this study. First is the fact that measurements made on direct radiographs are prone to errors and may overshadow the reliability of such studies. Yamada et al.[21] showed that standing lateral pelvis radiographs centered on S1 are more reliable than scoliosis radiographs, which are centered on T12. Although strict adherence to guidelines for obtaining standing lateral pelvis radiographs was maintained in this study, there remains a possibility of measurement errors. Another limitation is that since it was a retrospective case series study, despite the attempt to prevent selection bias, performance and detection bias could not be prevented, as randomization was not possible. Finally, although the measurement error was accepted as ±5°, repeated measurements were made by one experienced spine surgeon and senior resident and the high inter- and intra-observer agreement can help to minimize this error.

In conclusion, extreme weight loss resulting from bariatric surgery leads to functional improvement, and causes a decrease in PI over the SS. As there are opinions in literature to the contrary, there is a need for longer follow-up studies with better methodological design to be able to evaluate in more detail which mechanical or chemical pathways are dominant in this functional return or the reasons for the changes in pelvic parameters.

Ethics Committee Approval: The study protocol was approved by the Keçiören Training and Research Hospital Clinical Research Ethics Committee (date: 24.11.2020, no: 2084). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept: İ.D.; Design: HŞ.; Control/supervision, literature review, critical review: İ.D., H.Ş.; Data collection and/or processing, materials: F.E.Ö., D.Ö., H.B.; Writing the article, analysis and/or interpretation: F.E.Ö., M.A.

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