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Original article

Outcomes at 2 years follow-up of sacral fractures associated with unstable vertical pelvic ring injuries in obese patients: a multicentric retrospective study

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Abstract. *Background and aim:* Sacral fractures with concomitant unstable pelvic ring injuries are severe conditions which occur in patients involved in high-energy trauma. When operative treatment is required, high surgical experience on the field is mandatory, especially in a sub-polpulation of obese patients which have increased risk of complications. The aim of this multicentric retroscpective study was to describe and analyze clinical and radiological outcomes of sacral vertical fractures in obese patients with a minimum of 2 years follow-up. *Methods:* A total of 121 pelvic fractures admitted to Emergency Departments of three II level trauma centres from April 2015 to April 2021 were retrospectively reviewed. Demographics, injury mechanism, surgical data and complications were collected. The quality of life and the pelvic function were respectively measured by SF-12 questionnaires, Denis Work Scale and Majeed Score. The inter-rater agreement between the clinical scores and the Denis Work Scale was assessed. *Results:* A total of 19 patients were included in the study. The average follow up was 41.16 months. The average BMI was 38.63 and the mean abdominal circumference was 128.10 cm. The average Majeed and SF-12 scores were respectively 66.47 and 74.32. Five patients were able to return to their previous employment. The post traumatic life's quality and related dysfunctions are influenced by the high BMI. *Conclusions*: Faster recovery and early weight-bearing should be persued in order to minimize complications, expecially in obese patients. In these sample of patients, "triangular osteosynthesis" was the best treatment choice for sacral vertical fractures. (www.actabiomedica.it)

Key words: sacral fractures, pelvic ring fractures, vertical shear, obese patients, lumbopelvic fixation, BMI, abdominal circumference

Introduction

Sacral fractures are a major cause of death and disability in patients involved in high-energy trauma (1). These fractures can be unrecognized leading to unstable pelvic ring lesions with high impact on patients' mortality and morbidity. Moreover, sacral fractures are often associated with severe neurological lesions such as the stretching or tearing of the lumbosacral plexus roots (L4-S3) (1-3). The treatment of unstable vertical pelvic ring injuries associated with sacral fractures has many difficulties related both to reduction and fixation techniques; and this is especially true when we take into consideration a sub-polpulation of obese patients (4). According to the literature, incremental in body mass index is associated with an increased risk of complications after open reduction and internal fixation of acetabular fractures (5). In fact, in obese patients these

fractures require extensive surgical access in order to obtain good fracture site exposition. Therefore, a consolidated surgical experience in the field is mandatory. The treatment of sacral fractures aims to achieve anatomic reduction of the fracture, to protect the neural structures, to ensure adequate stability and to allow early mobilization. As far as we know, there is a lack in the literature about surgical treatment, rate of complication and clinical outcomes in a sub-population of obese patients witch sacral fracture in unstable perlvic ring injuries. This is the first multicentric retrospective study on the clinical and radiological outcomes of sacral vertical fractures in obese patients.

Patients and methods

This is a multicentric retrospective cohort study performed in three II level trauma centres in the southern of Italy. A total of 121 pelvic fractures admitted to our Emergency Departments (EDs) from April 2015 to April 2021 were retrospectively reviewed. Patients were included in the study according to the following criteria: age ranged from 16 to 75 years, Tile C pelvic ring fractures (6), weight ≥ 110 kg, abdominal circumference ≥ 120 cm, class II obesity - obesity (BMI 30.0-39.9 kg/m2), class III obesity - extreme obesity (BMI > 40 kg/m2) (7). Patients were excluded in case of less than two years follow up, bone metabolism or rheumatic diseases. Patients with oncological or infectious history were excluded too. Pelvic X-rays in AP position and CT scan with 3D reconstructions were collected. 3D-CT scans were essential to better understand the pattern of fracture, to analyze frangments dislocation and to study sacral foramina integrity. Moreover, CT scan included the lumbar spine in order to investigate the presence of spinal associated lesions. Injury Severity Score (ISS) was used to assess trauma severity in all politruamatized patients (8). Complete neurological examination according to American Spinal Injury Association (ASIA) (9) was also performed. Surgical treatment was chosen among various techniques currently described in literature as mentioned below (see Surgical Technique and Perioperative therapy) (2). Patients were treated according to the ethical standards of the Helsinki Declaration, and were invited to read, understand, and sign the informed consent form. Hospital records and clinical notes were reviewed to collect the following data: demographics, injury mechanism, associated lesions, operating times, perioperative bleeding, perioperative and post-operative complications, hospitalization, time of rehabilitation. The quality of life and the pelvic function were respectively measured by The Short Form Survey (SF-12) questionnaires (10), the Denis Work Scale (11) and the Majeed Score (MJS) (10). Bone healing and sacroiliac fusion were misured by X-rays assessed by examination of callus size, cortical continuity, and progressive loss of the fracture line (12) whereas CT scan was performed in case of doubts about consolidation (13). The evaluation end point was set at the last follow up.

Statistical analysis

Descriptive statistics were used to summarize the characteristics of the study group and subgroups: mean and standard deviation for continuous variables and frequency distribution (%) for categorical variables. The t-test was used to compare continuous outcomes. The Chi-square test or Fisher's exact test (in subgroups smaller than 10 patients) were used to compare categorical variables. The statistical significance was defined as $P < 0.05$. We used Pearson correlation coefficient (r) to compare the predictive score of outcomes and quality of life. Mean ages (and their range) were rounded at the closest year. The predictive score of outcomes and quality of life and their ranges were. approximated at the second decimal. Cohen's kappa coefficient (κ) was used to assess inter-rater agreement for categorical qualitative items, therefore calculating the concordance between different clinical scores (Majeed Score and SF-12) and the Denis Work Scale.

Surgical technique and perioperative therapy

Patients were placed in prone position on a radiolucent table. The surgical access to the sacrum depended on the chosen technique of reduction and osteosynthesis. It was performed a median longitudinal acczess to the sacrum without dissecting the sacrum-spinal muscle as suggested by Keel et al (14) in case of bilateral or unilateral lumbo-pelvic fixation (Figure 1). When transiliac internal fixation or posterior plating were performed, two separate incisions centered on

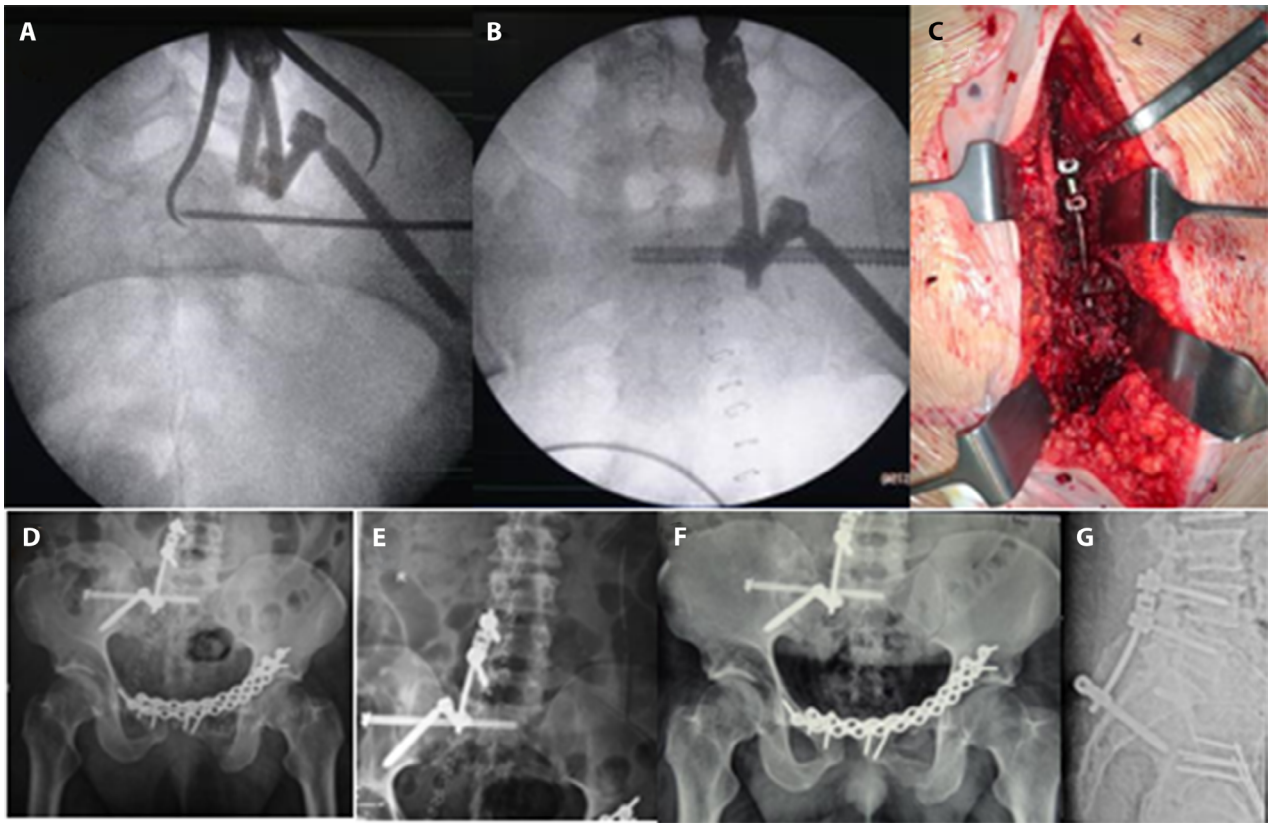

Figure 1. a,b) *C-arm* fluoroscopic X-ray image; c) intraoperative image; d,e) post-operative control;.f,g) follow-up after 1 year.

the PSIS (posterior superior iliac spine) were necessary. In case of direct sacral plate fixation, we use the approach evidenced by Fowler et al (15). All our cases demanded for an anterior approach, which was carried out through a Pfannenstiel, a Stoppa modified or an Anterior Combined Endopelvic (ACE) approach (16). Appropriate antibiotic therapy was administered 30 minutes before surgical operation. Patients with neurological deficits have been subjected to the NASCIS protocol (17, 18). All the included patients received low molecular weight heparin and A-V foot compression system to prevent venous thrombosis, until complete weight-bearing was achieved (19).

Results

A total of 19 patients were included in the study. Ninety-seven patients were excluded due to the lower BMI, 5 patients had an oncological or infectious. The average follow up was 41.16 ±12.30 months (range 24-62). The mean age at the time of trauma was 36.29 ±8.77 (range 25-56) years old and the male/female ratio was 2.8 (14:5). The right one was the most injured side (49.37%) whereas 3 cases (15.79%) were bilateral. The work activity was mostly represented by the industrial sector. The average BMI was 38.63 ±2.69 (range 35.6-44.6) and the mean abdominal circumference was 128.10 ±9.10 cm (range 120-156).

Motor vehicle accidents were the most frequent cause of trauma, followed by falls from the heigh. In particular, suicide attempts were 4 cases out of 6. The mean ISS was 32.84 ±11.90 (range 8-51). Among concomitant lesions, acetabular fractures were associated in 4 (21.05%) cases whereas 13 (68.42%) patients had sacral nerve roots injuries. In 8 (42.10%) cases there were neurological deficit according ASIA score. Demographics and pre operative data are summarized in Table 1.

Closed reduction and internal fixation (CRIF) was the most frequent treatment choice. The most

Table 1. Demographics, fracture classification and type of fixation.

Patient	Sex	Age (yrs)	Side	Follow-up (mo)	Occupation	Associated Injury	Injury Mechanism	Tile Classification + Denis Classification	BMI	Abdominal Circumferance	Neuroligical Injury According ASIA	Type of Fixation SIJ	Reduction	X-Rays Reduction
1	M	49	R	38	Retired	None	MCV	C1+II	36	120	NONE	SP+IS	Anatomic	Excellent
2	F	42	R	38	Homemaker	Multiple	Fall-Suicide	C1+II	35	120	R Sciatic Nerve		Satisfactory	Excellent
3	M	29	B	56	Farmer	Multiple + R BC	MVC	C3+I	39	132	NONE	PP	Anatomic	Excellent
4	M	44	R	62	Professor	Multiple	MVC	C1+IIIA	35	128	R Sciatic Nerve	SP+IS	Satisfactory	Fair
5	M	30	L	37	Military	None	MVC	C1+II	37	136	NONE	2 x SR	Satisfactory	Fair
6	M	41	R	48	Office worker	Multiple	MVC	C1+IIIB	39	139	NONE	SP+IS	Anatomic	Excellent
7	F	42	L	27	Professor	Multiple	Fall-Suicide	C1	37	122	NONE	SP+IS	Good	Good
8	M	39	L	32	Track driver	Upper Arms	MVC	C1 + IIB	38	125	NONE	SP+IS	Anatomic	Good
9	M	28	L	29	Student	Multiple	MVC	C1 +IIIA	38	124	NONE	2 x SR	Anatomic	Good
10	M	52	R	38	Taxi driver	Multiple	MVC	C2 + III	41	123	R Scatic	PP	Anatomic	Good
11	F	L	B	56	Nurse	Right Acetabular BC	MVC	C3+IIIE	35	120	Complete Sacral Plexus deficit + B Sciatics	PA	Satisfactory	Fair
12	M	25	L	60	Criminal	Acetabular Right Trans	MCV	C1+IIIb	42	135	Penus Erection	PP	Anatomic	Excellent
13	M	34	R	24	Carpenter	Multiple	Fall	C1	40.6	122	NONE	PA	Anatomic	Good
14	M	29	L	40	Plumber	Lower limbs	Fall	C2+IIIC	38.6	126	Pelvic Floor	SR	Satisfactory	Good
15	F	48	R	57	Umployed	Multiple	Fall-Suicide	C1+I	42.1	135	Complete Sacral Plexus deficit	CS	Satisfactory	Fair
16	M	36	L	48	Farmer	Multiple + L AC	MCV	C1+I	36.5	123	NONE	CS	Anatomic	Excellent
17	M	37	R	36	Office worker	Multiple	MCV	C1+I	37.8	128	NONE	CS	Anatomic	Good
18	M	56	R	27	Medical Doctor	Multiple	MCV	C1+IIIA	35.3	120	NONE	PP	Anatomic	Good
19	F	38	B	29	Employed	Multiple	Fall-Suicide	C3+IIE	44.6	156	Complete Sacral Plexus deficit paraplegic	PA	Unsatisfactory	Poor

AC, anterior column; B, bilateral; BC, both column; F, female; L, left; M, male; MVC, motor vehicle crash; R, right; Trans, transverse wall; PP, posterior SIJ plate; AP, anterior SIJ plate; IS; Ileo Sacral Screws; CS cannulated screws; SP, Spino Pelvic. SR, Sacral Rod.

common type of fixation was the monolateral spine-pelvic plus sacral screw fixation in 5 (26.32%) cases. In 11(57.89%) cases anatomical reduction was obtained during itraoperative examination while at sudden post operative X-rays reduction was considered excelet in 6 (31.58%) cases only. Figures 2,3,4 and 5 describe the relations between BMI/reduction, abdominal circumference/X-rays BMI-Majeed Score and BMI-SF12.

Surgery was performed 13.05 ±6.49 days (range 4-24) after trauma. The average operative time was 166.32 ±40.60 (range 106-248) in minute and the blood loss was 963.16 ±594.30 (range 237-2368) in mL. Weight bearing was conceded at 9.26 ±4.43 (range 3-22) weeks from operation. The average time of wounds closure was 30.63 ±21.14 (range 21-94) in weeks whereas 4 (21.05%) cases had wound closure problems. Moreover, as concerns complication, post-operative neurological injuries occurred in patients n°18 and n°19. The most common peri-surgery complication was DVT. The average time of hospitalisations were 29.53 ±10.01 (range 16-56) in days. At the last follow-up, the average Majeed and SF-12 scores were respectively 66.47 ±10.31 (range 44-86) and 74.32 ±8.44 (range 56-93) in points. Five patients (26.32%) were able to return to their previous employment. The mean correlation between Denis Work scale and clinical scores were measured according towas Cohen and were respectively: $\kappa = 0.67 \pm 0.08$ for Majeed Score ($p > 0.05$), $\kappa = 0.81 \pm 0.13$ for SF-12 ($p < 0.05$). Operative and post-operative data are summarized in Table 2.

Discussion

The problem of high BMI and sacral fractures

Sacral fractures are very uncommon in orthopaedic patients; in particular, in obese patients, could be unrecognized in the initial radiography in emergency room. In our sample of patients, the relationship between BMI and the Majeed Score shows a logarithmic mean that goes down the low and also the dispersion of patients compared to the average is very wide and this is affected by the bigger BMI and the post traumatic annexed dysfunctions. The relationship between BMI and the SF-12 shows a logarithmic mean that goes down the low and also the dispersion of patients compared to the average is very wide and this is affected by the bigger body mass and the post traumatic life's quality. Figures 2 and 3 show R^2 values of 0.0129 and 0.0121 respectively. R^2 values tell us the proportion of the variance in the dependent variable that can be explained by the independent variable in the regression model. In both figures the independent variable is BMI. The low R^2 value tells us that BMI explains little of the variance in the Majeed score (figure 2) and SF-12 (figure 3). Thus, these data give little information about the BMI effect on the Majeed score and SF-12. Physical examination and X-rays are very useful for the diagnosis, but it is still essential to obtain a CT scan in doubt cases (1). The number of obese people in the USA has increased by 50% in the last 20 years. In Italy, the increase of obesity experienced in the last five years (+ 9%) was extensive among young adults, especially in males. It is estimated that the phenomenon presently affects 10.5% of males and 9.1% of females (20). Arabi et al (21) suggest that obese patients have an increased momentum during the deceleration consequent to trauma because of their body mass. This theory was also confirmed by Kent et al (22): obese patients need more restraint before the forward motion is stopped due to their greater kinetic energy. In support of these claims these authors report that the obese patient is less exposed to lateral side injuries thank to the so called "cushioning effect" while it is more susceptible to antero-posterior traumas.

Risk and complication in sacral fracture

Porter et al (23) demonstrated that the overall rate of complications in obese patients is 63% compared with 24% of those with normal weight. In particular, patients with higher BMI have 46% more chance to develop surgical wound infections. The infection risk in these patients depends on factors related to comorbidities (heart disease, diabetes and vascular disease), habitus (less vascularized subcutaneous adipose tissue), surgical time and mechanism of trauma (24, 25). To date, considering this large number of complications, it is still debated if the surgical treatment and the operative fixation techniques should be modified

Table 2. Peri operative and follow up, results, complications, outcomes and work capacity.

Patient	Surgery Days After Trauma	Length of surgery In minute	Blood Loose In ml	Weight bearing in time In weeks	Wounds time In days desuetude	New Neuroligical Injury According ASIA After surgery	Miscellaneous complication	Time of hospitalizations In days	Time of Rehabilitaion In weeks	Majeed Score	SF-12	Works Denis Scale
1	7	183	936	7	21	NONE	NONE	23	26	63	74	W3
2	20	248	1236	8	21	NONE	NONE	24	28	52	56	W5
3	7	182	879	8	22	NONE	NONE	35	32	61	67	W4
4	5	153	726	7	21	NONE	NONE	46	34	59	78	W3
5	4	118	663	3	21	NONE	NONE	42	23	77	77	W3
6	4	167	565	3	21	NONE	TEV	38	24	63	72	W4
7	12	172	863	6	21	NONE	TEV	31	26	64	77	W3
8	16	188	782	12	56	NONE	Skin infection, abdominal wound diseases	33	25	66	79	W2
9	17	106	774	10	74	NONE	Abdominal and sacral wound drsease,	45	25	69	75	W2
10	18	124	872	16	42	NONE	NONE	24	23	71	74	W2
11	19	204	2356	22	94	NONE	Sacral Morel-Lavallée lesion corona mortis injury	61	54	58	63	W5
12	23	206	1872	8	21	NONE	Femoral Artery Injury	35	32	82	85	W1
13	16	106	567	10	21	NONE	Femoral Vessels Thrombosis	34	23	74	81	W2
14	10	156	693	12	21	NONE	NONE	30	26	68	76	W3
15	8	167	456	7	21	NONE	NONE	22	27	58	64	W5
16	7	149	823	7	21	NONE	TEV	26	35	86	93	W1
17	13	157	237	7	21	NONE	TEV	42	16	72	77	W2
18	24	132	632	11	21	Penus Erection		46	26	76	82	W1
19	18	242	2368	12	21	NONE	Death for new suicide attempt	66	56	44	62	W5

Denis work scale: W1: Return to previous employment (heavy labor) or physically demanding activities; W2: Able to return to previous employment (sedentary) or return to heavy labor with restrictions; W3: Unable to return to previous employment but works full time at new job; W4: Unable to return to full time work; W5: No work, completely disabled.

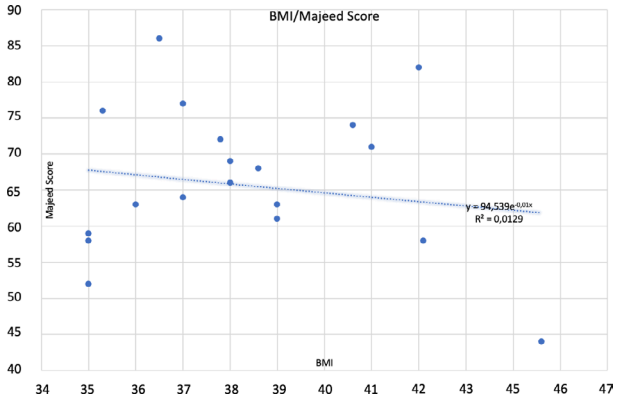

Figure 2. The relationship between BMI and the Majeed Score shows a logarithmic mean that goes down the low and also the dispersion of patients compared to the average is very wide and this is affected by the bigger BMI and the post traumatic annexed dysfunctions.

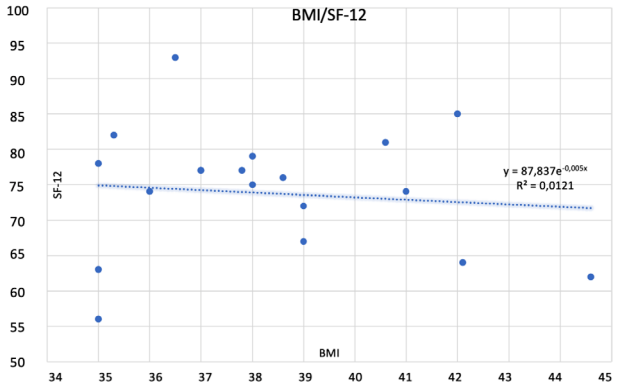

Figure 3. The relationship between BMI and the SF-12 shows a logarithmic mean that goes down the low and also the dispersion of patients compared to the average is very wide and this is affected by the bigger BMI and the post traumatic life's quality.

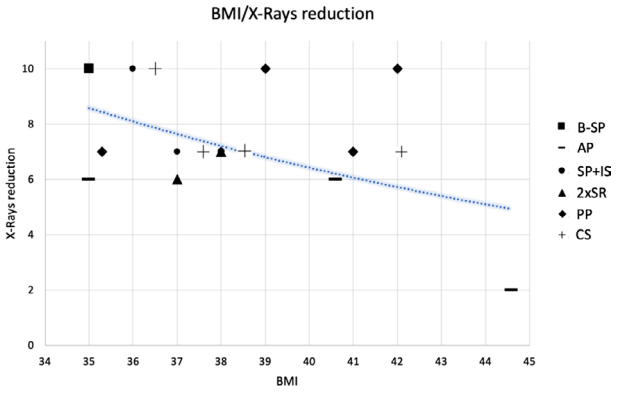

Figure 4. The figure shows the relationship between BMI and the quality of radiographic reduction The equation R^2 value is 0.0995. The meaning of the abbreviations are described below: B-SP, Bilateral – Spino Pelvic; AP, Anterior Plate; SP + IS, Spino Pelvic – Ileosacral Screw; 2xSR, 2 x Sacral Road; PP, Posterio SIJ (Sacro Iliac Joint) Plate; CS, Cannulated Screw.

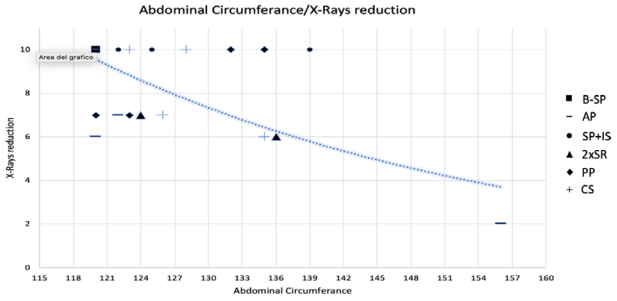

Figure 5. The figure shows the relationship between abdominal circumference and the quality of radiographic reduction. The equation R^2 value is 0.2179. The meaning of the abbreviations are described below: B-SP, Bilateral – Spino Pelvic; AP, Anterior Plate; SP + IS, Spino Pelvic – Ileosacral Screw; 2xSR, 2 x Sacral Road; PP, Posterio SIJ (Sacro Iliac Joint) Plate; CS, Cannulated Screw.

in case of acetabular or pelvic fractures in the obese population (23, 24). Porter et al (23), Carson et al (24) and Migliore et al (25) reported an increased rate of pulmonary complications and longer time of hospitalization. Moreover, several studies demonstrate that surgical time and intraoperative blood loss are higher compared to normal weight, resulting in a major risk of surgical site infection. Nicodemo et al (26) achieved good to excellent results in the 91% of sacral vertical fractures among obese patients. A single bad result was obtained because of the delayed timing of surgery. In particular, percutaneous treatment was discouraged when performed more than 15 days after trauma, recommending to operate as soon as possible this category of patients.

The treatment of sacral fracture

The treatment of pelvic ring injuries in the obese population is technically difficult and fraught with complications. In order to prevent them, we must

ensure that patients are receiving high-quality health care and being judiciously monitored to minimize complications and aggressively manage those when occur (27). Many surgical options are available for the treatment of sacral vertical fractures: ileo-sacral screw fixation, ileo-ilial osteoynthesis (plate knight, Barr screw, transiliac internal fixation), plate fixation and lumbo-pelvic fixation (2). In our opinion, percutaneous ileo-sacral screws fixation should be indicated in case of undisplaced fractures. This technique should be performed by an expert surgeon as it demands for a long learning curve to understand intraoperative fluoroscopic imaging: the insertion hallway is only 20mm width and the "huge mass" could prevent a correct display of the entry point, increasing the risk of L5 root injuring in the obese patient (28). In addition, ileo-sacral screw fixation alone could not achieve an adequate mechanical stability in these patients. In fact, Griffin et al (29) underlined failures occurred in vertical sacral fractures treated with ileo-sacral screw alone. The transiliac internal fixator proposed by Dienstknecht et al (30) is a type of minimally invasive osteosynthesis indicated in case of sacroiliac fracture-dislocation or transforaminal sacral wing fracture. In this surgical technique, pedicle screws are placed into the iliac wings from the posterior superior iliac spines and they consequentely are connected through rods. It ensures even greater stability than the ileo-sacral screw fixation or the anterior sacroiliac plate but it is less invasive and presents a very low risk of neurovascular injury (31). The lumbo-pelvic fixation is indicated in sacral fractures with transforaminal comminution (Denis type II), when there is sacral instability or spinopelvic dissociation. The lumbo-pelvic fixation is the only surgical procedure which allows to bypass the sacrum and the sacroiliac joint. Through this surgical treatment we provide an effective force sharing and allow an early weight bearing, avoiding complications associated with prolonged immobilization. However, lumbo-pelvic fixation demands for some spinal surgical skills and could need a wide vertebral exposure when percutaneous technique is not currently managed. In this case, as reported by Sagi et al (32), it is of extreme importance the L5-S1 articular facets status. Hu et al. (33) reported the advantages of the "triangular osteosynthesis". This technique combines lumbo-pelvic with ileo-sacral screw fixation determining absolute stability of the fracture as confirmed by several biomechanical studies (34, 35). Pelvic ring fractures heavily impact on daily activities of the injured patients (36, 37). Traumatized obese patients develop psychological insecurity and can experience some types of mental illness which extremely affect their quality of life (36). Papasotiriou's univariate analysis confirmed that return to work was significantly related to the accident site (labor or not), the magnitude of the accident's force, concomitant injuries, duration of hospitalization, Majeed score, and complications such as limp and pain as well as urologic and sexual complaints ($p < 0.05$ for all). On multiple logistic regression analysis, the accident sustained out of work (odds ratio: 6.472, 95% confidence interval: 1.626-25.769) and Majeed score (odds ratio: 3.749, 95% confidence interval: 2.092-6.720) were identified as independent predictive factors of full return to work (37-41). The knowledge of the characteristics of the lesions and of the classification systems, as well as an accurate assessment of the anatomo-functional repercussions, represent therefore the fundamental prerequisites for the correct assessment of physical damage (42).

Limitations of the study

The main limitation of the current study is represented by the small number of included patients and the not homogeneous surgical treatments. Therefore, this sample of patients could not be representative of the population. Moreover, the measurements and intervention were made without randomization, which have intrinsic potential for bias. Finally other limiting factors of the study could be: the potential for regression to the mean, the presence of temporal confounders and the mention of subjective score.

Conclusions

Vertical sacral fractures are challenging orthopedic injuries, especially in obese patients. Most of them are associated with pelvic ring fractures and other concomitant lesions. CT scans are crucial for proper diagnosis and subsequent best treatment choice. Surgical

techniques which ensure greater mechanical stability associated with a strict respect of soft tissues should be performed. Faster recovery and early weight-bearing should be persued in order to minimize complications and reduce postoperative morbidity. Therefore, in the light of findings and based on these considerations, the use of the internal fixator and "triangular osteosynthesis" result the best treatment choice for sacral vertical fractures in obese population.

List of Abbreviations: EDs: Emergency Departments; BMI: Body Mass Index; ASIA: American Spinal Injury Association; AP: antero-posterior; PSIS: posterior superior iliac spine; ACE: Anterior Combined Endopelvic; NASCIS: National Acute Spinal Cord Injury Study; ISS: Injury Severity Score; CRIF: Closed reduction internal fixation; DVT: Deep Vein Thrombosis

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Ethic Committee: All patients gave the informed consent prior being included into the study. All procedures involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments. For this type of study, any statement relating to studies on animals is required.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Authors Contribution: This manuscript is the result of a collaborative effort. LM, AS, FL, DDM– conception, methodology, drafting, revision; GR – drafting, editing, revision; AF, PG – supervision, editing, revision; GR, RE – methodology, drafting, revision, conception, supervision, editing

References

1. Falzarano G, Medici A, Carta S. et al. The orthopedic damage control in pelvic ring fractures: when and why-a multicenter experience of 10 years' treatment. J Acute Dis 2014:201-206. doi: 10.1016/S2221-6189(14)60044-5
2. Falzarano G, Rollo G, Bisaccia M. et al. Percutaneous screws CT guided to fix sacroiliac joint in tile C pelvic injury. Outcomes at 5 years of follow-up. SICOT J. 2018;4:52. doi: 10.1051/sicotj/2018047.
3. Rovere G, Smakaj A, Perna A. et al. Correlation between traumatic pelvic ring injuries and sexual dysfunctions: a multicentric retrospective study. Int Orthop. 2023 Jun;47(6):1407-1414. doi: 10.1007/s00264-023-05767-0
4. Morris BJ, Richards JE, Guillamondegui OD et al. Obesity increase early complications after high-energy pelvic and acetabular fractures. Orthopedics. 2015 Oct;38(10):e881-7. doi: 10.3928/01477447-20151002-54
5. Karunajar MA, Shan SN, Jerebek S. Body mass index as a predictor of complications after operative treatment of acetabular fractures. J Bone Joint SurgAm 2005; 87(7): 1498-1502
6. Furey AJ, O'Toole RV, Nascone JW. et al. Classification of pelvic fractures: analysis of inter- and intraobserver variability using the Young-Burgess and Tile classification systems.Orthopedics. 2009;32(6):401. doi: 10 .3928/01477447-20090511-05.
7. De Lorenzo A, Soldati L, Sarlo F, Calvani M, Di Lorenzo N, Di Renzo L. New obesity classification criteria as a tool for bariatric surgery indication. World J Gastroenterol. 2016;22(2):681-703. doi: 10.3748/wjg.v22.i2.681.
8. Gokalp MA, Hekimoglu Y, Gozen A, Guner S, Asirdizer M. Evaluation of Severity Score in Patients with Lower Limb and Pelvic Fractures Injured in Motor Vehicle Front-Impact Collisions. Med Sci Monit. 2016;22:4692-4698.
9. Adelved A, Tötterman A, Glott T, Madsen JE, Røise O. Functional outcome 10 years after surgical treatment of displaced sacral fractures. Spine (Phila Pa 1976). 2012;37(16): E1009-16. doi: 10.1097/BRS.0b013e31823a0d83.
10. Saracco M, Fidanza A, Necozione S, Maccauro G, Logroscino G. Could Short Stems THA Be a Good Bone-Saving Option Even in Obese Patients?. J Clin Med. 2022;11(23):7114. Published 2022 Nov 30. doi:10.3390 /jcm11237114.
11. Denis S, Shannon HS, Wessel J, Stratford P, Weller I. Association of low back pain, impairment, disability & work limitations in nurses. J Occup Rehabil 2007; 17(2): 213-226.
12. Chan J, Sari I, Salonen D, Inman RD, Haroon N. Development of a Screening Tool for the Identification of Sacroiliitis in Computed Tomography Scans of the Abdomen. J Rheumatol. 2016;43(9):1687-94. doi: 10.3899/jrheum.150939.
13. Fidanza A, Rossi C, Iarussi S, Necozione S, Indelli PF, Calvisi V. Proximal humeral fractures treated with a low-profile plate with enhanced fixation properties. J Orthop Sci. 2022;27(6):1298-1303.
14. Keel MJ, Benneker LM, Siebenrock KA, Bastian JD. Less invasive lumbopelvic stabilization of posterior pelvic ring instability: technique and preliminary results. J Trauma. 2011;71(3):E6270. doi: 10.1097/TA.0b013e3182092e66.
15. Fowler TT, Bishop JA, Bellino MJ. The posterior approach to pelvic ring injuries: A technique for minimizing

soft tissue complications. Injury. 2013;44(12):1780-6. doi: 10.1016/j.injury.2013.08.005.
16. Rocca G, Spina M, Mazzi M. Anterior Combined Endopelvic (ACE) approach for the treatment of acetabular and pelvic ring fractures: A new proposal. Injury. 2014;45 Suppl 6:S9S15. doi: 10.1016/j.injury.2014.10.016.
17. Fehlings MG, Wilson JR, Harrop JS, et al. Efficacy and Safety of Methylprednisolone Sodium Succinate in Acute Spinal Cord Injury: A Systematic Review. Global Spine J. 2017;7(3 Suppl):116S-137S. doi: 10.1177/2192568217706366.
18. Medici A, Di Salvatore MG, Pezzella R, Fidanza A, De Simone AM, Calvisi V. Bilateral fractures of acetabulum in a young girl with osteogenesis imperfecta and epilepsy. Trauma Case Rep. 2019;25:100265
19. Randelli F, Romanini E, Biggi F, et al. II Italian intersociety consensus statement on antithrombotic prophylaxis in orthopaedics and traumatology: arthroscopy, traumatology, leg immobilization, minor orthopaedic procedures and spine surgery. J Orthop Traumatol. 2013;14(1):1-13. doi: 10.1007/s10195-012-0214-y
20. De Marchi B, Casati S, Tarlao G. Stakeholder appraisal of policy options for responding to obesity in Italy. Obes Rev. 2007;8 Suppl 2:83-9.
21. Arabi S, Wahl WL, Hemmila MR, Kohoyda-Inglis C, Taheri PA, Wang SC. The cushion effect. J Trauma 2003; 54(6): 1090-3
22. Kent RW, Forman JL, Bostrom O. Is There Really a "Cushion Effect"?: A Biomechanical Investigation of Crash Injury Mechanisms in the Obese. Obesity (Silver Spring). 2010;18(4):749-53.
23. Porter SE, Graves ML, Zhen Russel GV. Operative experience of pelvic fractures in the obese. ObesSurg 2008; 18:702-708
24. Carson JT, Shah SG, Ortega G, Thamyongkit S, Hasenboehler EA, Shafiq B. Complications of pelvic and acetabular fractures in 1331 morbidly obese patients (BMI ≥ 40): a retrospective observational study from the National Trauma Data Bank. Patient Saf Surg. 2018 Aug 29;12:26. doi: 10.1186/s13037-018-0172-2.
25. Migliore E, Pagano E, Mirabelli D, et al. Hospitalization rates and cost in severe or complicated obesity: an Italian cohort study. BMC Public Health. 2013;13:544. doi: 10.1186/1471-2458-13-544.
26. Nicodemo A, Cuocolo C, Capella M, Deregibus M, Massè A. Minimally invasive reduction of vertically displaced sacral fractures without use of traction table. J Orthopaed Traumatol 2011; 12:49-55
27. Purcell KF, Bergin PF, Spitler CA, Graves ML, Russell GV. Management of Pelvic and Acetabular Fractures in the Obese Patient. Orthop Clin North Am. 2018;49(3): 317-324. doi: 10.1016/j.ocl.2018.02.005.
28. Salazar D, Lannon S, Pasternak O, Schiff A, Lomansney L, Mitchell E, Stover M. Investigation of bone quality of the first and second sacrale segments amongst trauma patients: Concerns about iliosacral screw fixation. J Orthop Traumatol. 2015; 16(4): 301-8.
29. Griffin DR, Starr AJ, Reinert CM. Vertically unstable pelvic fractures fixed with percutaneous ileo-sacral screw: does posterior injury pattern predict fixation failure? J Orthop Trauma. 2003;17:399-405
30. Dienstknecht T, Berner A, Lenich A, Nerlich M, Fuechtmeier B. A minimally invasive stabilizing system for dorsal pelvic ring injuries. Clin Orthop Relat Res. 2011 Nov;469(11):3209-17.
31. Salášek M, Jansová M, Křen J, Pavelka T, Weisová D. Biomechanical comparison of a transiliac internal fixator and two iliosacral screws in transforaminal sacral fractures: a finite element analysis. Acta Bioeng Biomech. 2015;17(1):39-49.
32. Sagi HD. Technical aspects and recommended treatment algorithms in triangular osteosynthesis and spinopelvic fixation for vertical shear transformational sacral fractures. J Ortop Trauma 2009; 23:354-360
33. Hu X, Pei F, Wang G, He J, Kong Q, Tu C. Application triangular osteosynthesis for vertical unstable sacral fractures. Eur Spine J. 2013;22(3):503-9.
34. Schildhauer TA, Ledoux WR, Chapman JR, Henley MB, Tencer AF, Routt ML jr. Triangular Osteosynthesis and ileo-sacral screw fixation for unstable sacral fractures: a cadaveric and biomechanical evaluation under cyclic loads. J Orthop Trauma 2003; 17:22-31
35. Salari P, Moed BR, Bledsoe JG. Supplemental S1 fixation for type C pelvic ring injuries: biomechanical study of a long iliosacral versus transsacral screw. J OrthopTraumatol. 2015 Dec;13(4):293-300
36. Reynolds M, Driver S, Bennett M, Patel S, Rainey E, Warren AM. Examining the relationship between obesity and mental health outcomes among individuals admitted to a level I trauma centre. Clin Obes. 2018 Oct;8(5):337-344. doi: 10.1111/cob.12264.
37. Papasotiriou AN, Prevezas N, Krikonis K, Alexopoulos EC. Recovery and Return to Work After a Pelvic Fracture. Saf Health Work. 2017 Jun;8(2):162-168. doi: 10.1016/j.shaw.2016.10.003.
38. Ciolli G, Caviglia D, Vitiello C. et al. Navigated percutaneous screw fixation of the pelvis with O-arm 2: two years' experience. Med Glas (Zenica). 2021 Feb 1;18(1):309-315. doi: 10.17392/1326-21. PMID: 33480224.
39. Rovere G, Perna A, Meccariello L. et al. Epidemiology and aetiology of male and female sexual dysfunctions related to pelvic ring injuries: a systematic review. Int Orthop. 2021 Oct;45(10):2687-2697. doi: 10.1007/s00264-021-05153-8. Epub 2021 Aug 10. PMID: 34378143; PMCID: PMC8514382.
40. Florio M, Capasso L, Olivi A, Vitiello C, Leone A, Liuzza F. 3D - Navigated percutaneous screw fixation of pelvic ring injuries - a pilot study. Injury. 2020 Aug;51 Suppl 3:S28-S33. doi: 10.1016/j.injury.2020.07.025. Epub 2020 Jul 10. Erratum in: Injury. 2021 Apr;52(4):1103. PMID: 32723529.

41. Napoli N, Rini GB, Serber D, et al. The Val432Leu polymorphism of the CYP1B1 gene is associated with differences in estrogen metabolism and bone density. Bone. 2009 Mar;44(3):442-8. doi: 10.1016/j.bone.2008.09.018. Epub 2008 Oct 15. PMID: 18977467; PMCID: PMC3966713.
42. Basile G, Passeri A, Bove F, Accetta R, Gaudio RM, Calori GM. Pelvic ring and acetabular fracture: Concepts of traumatological forensic interest. Injury. 2022 Feb;53(2): 475-480. doi: 10.1016/j.injury.2021.11.063. Epub 2021 Nov 26. PMID: 34865817.

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