RESEARCH ARTICLE

Subtrochanteric Fractures of The Femur: May a Short Nail Be a Reliable Option?

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Abstract

Objectives: Treatment of subtrochanteric fractures of the proximal femur may be challenging due to their anatomical and biomechanical features. Intramedullary nails are the most frequently used devices, although there is no consensus concerning their optimal length. The aim of this study is to compare the functional and radiological outcomes of the fragility subtrochanteric fractures treated with short versus long cephalomedullary nails.

Methods: A retrospective cohort study was performed including all over-65-year-old patients that underwent surgery with a cephalomedullary nail between January 2013 to December 2020 due to a subtrochanteric fracture. The primary outcome was the presence of mechanical complications (cut out, cut in, varus consolidation, nonunion and nail breakage). Accuracy of the reduction, distance from the fracture line to most proximal distal screw, operative time and Palmer Mobility score were also analyzed.

Results: Ninety-five patients were included. There were not significant differences in complication rate, Parker mobility score nor quality of reduction between both cohorts. Patients with a good radiological reduction presented no complications, those with an acceptable reduction presented a complication rate of 35.5% and it raised to 53.3% in poorly reduced ones (P=0.002). The complication rate was higher in the <5cm distance group (58.33%) than in the >5cm distance group (22.64%) (P=0.014).

Conclusion: Anatomical reduction may be the key factor in the management of subtrochanteric fractures, in order to avoid complications. The chosen device working length should also be taken into account to treat these challenging injuries.

Level of evidence: IV

Keywords: Long nail, Nonunion, Reduction, Short nail, Subtrochanteric fracture

Introduction

Subtrochanteric fractures of the proximal femur involve the area five centimeter (cm) distal to the lesser trochanter. They account for approximately five percent of all hip fractures. A bimodal distribution is reported, affecting geriatric population with low energy trauma and young adults involved in high energy trauma.[1,2]

Treatment of subtrochanteric femoral fractures may be challenging due to their anatomical and biomechanical features. This area is subjected to high compressive and tensile forces. Additionally, strong adjacent muscles act as deforming forces over the fragments and the common lack of medial buttress promote the varus deformity. These impair the anatomic reduction of the fractures and their maintenance. The presence of thick cortical bone might have reduced blood circulation which may impair healing.[3-5]

Hence, complications are more common than in the intertrochanteric region. These include varus deformity, non-union, and failure of internal fixation and shortening of the lower limb.[3]

Intramedullary nails are the most frequently used devices for these proximal femur fractures, because of

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their biomechanical advantages over extramedullary implants.[6,7] There is a lack of consensus concerning the optimal length of the intramedullary nails.[8] Increasing fracture complexity enhance the use of long nails versus standard short nails. However, it is unclear whether nail length influences healing in unstable proximal femur fractures.[9-11]

The aim of this study is to compare the functional and radiological outcomes of the fragility subtrochanteric fractures treated with short versus long cephalomedullary nails in our institution.

Materials and Methods

An observational retrospective cohort study was performed. It included all over-65-year-old patients who were admitted at our institution with the diagnose of fragility-type subtrochanteric fracture and underwent surgery with cephalomedullary short nail or long nail between January 2013 to December 2020. The included fractures were the 31.A3.1, 31.A3.3, 32.A, 32.B or 32.C (AO/OTA) types that were located within the 5cm segment distal to the lesser trochanter.[12] The exclusion criteria were pathologic fractures, high energy trauma fracture and those fractures whose pattern reached further than the subtrochanteric area.

All patients underwent surgery under spinal anesthesia on a fracture table. The choice of long or short nail depended on the surgeon's preference, without any protocolized criteria. Nailing was performed according to the surgical technique. Patients were sat on the first postoperative day and partial weight bearing was allowed between the second postoperative day to the eighth postoperative week, at the discretion of the surgeon.

Two different cohorts were defined: one treated with cephalomedullary standard short nails, Affixus 180mm Hip Fracture Nail System® (Zimmer Biomet, Warsaw, IN, USA) or PFNA 240mm nail (De Puy-Synthes, West Chester, PA, USA) and the other cohort included those patients treated with cephalomedullary long nails (260-460mm), Affixus Hip Fracture Nail System® (Zimmer Biomet, Warsaw, IN, USA). [Figure 1 and Figure 2]

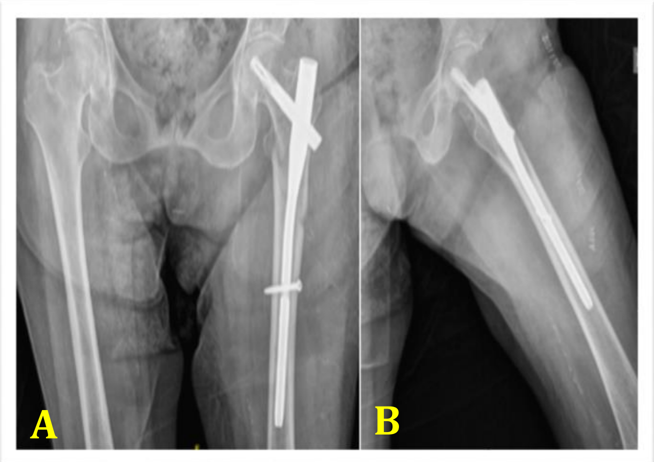

Figure 1. (A) Anteroposterior radiograph of the left hip of a patient with AO/OTA 32A fracture treated with a short intramedullary hip nail. (B) Postoperative lateral radiograph of the left hip of the same patient

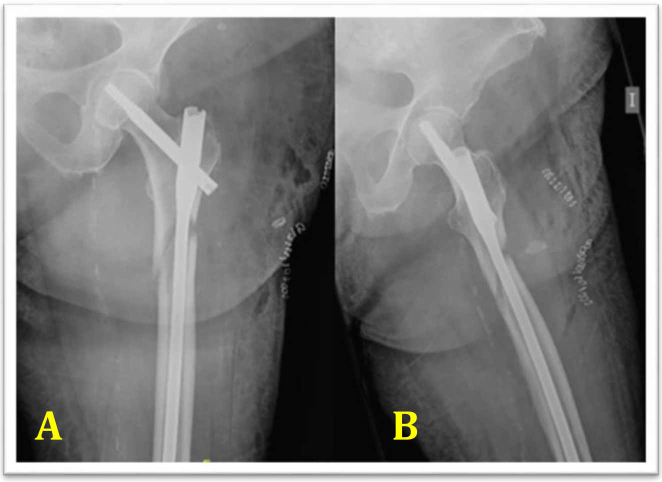

Figure 2. (A) Anteroposterior radiograph of the left hip of a patient with AO/OTA 32A fracture treated with a long intramedullary hip nail. (B) Postoperative lateral radiograph of the left hip of the same patient

Clinical and radiological results were analyzed at the last follow-up visit registered. The minimum follow-up was three months.

The primary outcome was the presence of mechanical complications, which were defined as cut out, cut in, varus consolidation, nonunion over a nine-month follow-up period and nail breakage. Radiographic fracture healing was defined as presence of trabeculation and cortical bridging in at least three cortices in two orthogonal projections.[13]

The secondary outcome was the evaluation of the postoperative Parker mobility score which is a composite measurement of hip fracture patient mobility (patient's mobility indoors, outdoors and during shopping). For each of the three situations the mobility has to be scored on: no difficulty (3 points), with an aid (2 points), with help from another person (1 point) or not at all (0 points). The highest overall score of 9 indicates the best possible mobility.[14]

Preoperative analyzed data were age, sex, AO type of fracture and Charlson comorbidity index. Need for blood transfusion, infection rate, accuracy of the reduction according to Baumgaertner criteria Table 1, distance from the fracture line to the most proximal distal screw and operative time were also registered [Table 1].[15]

Table 1. Baumgaertner criteria[14]
I. Alignment
- Anteroposterior view: normal or slight valgus neck-shaft angle (≤10º)
- Lateral view: leds than 20° of angulation
II. Displacement
- Anteroposterior view: less than 4 mm of displacement of any fragments
- Lateral view: less than 4 mm of displacement of any fragments
Reduction quality
Good: aligment and displacement criteria met
Acceptable: only one criterion met
Poor: neither criterion met

The statistical analysis was performed with SPSS software (version 21.0, SPSS Inc, Chicago, IL, USA). Analysis of normality was performed with Kolmogorov-Smirnov Z test. All data were normally distributed. Student's T test was used to compare quantitative data and Pearson chi-square and Fisher's exact test for qualitative data. Statistical significance was accepted at *P<0.05*.

The study was approved by the Clinical Research Ethics Committee of our institution (4662/22-12-21) and performed in accordance with the ethical standards of the Declaration of Helsinki.

Results

Ninety-five patients were included in our study over the 8-year-period. All data were collected from the electronic records. Thirty patients were excluded because their follow-up was shorter than 120 days. The mean follow-up was 450.5(361.6) days in the short nail group and 418.6(252.8) days in the long nail group (P=0.68). The overall mean age was 85.23(6.31) years and 82% of the patients included in our study were women. The overall average Charlson index was 6.20(1.91) and preoperative mean Parker Mobility score was 6.14(2.66) [Table 2]. Table 2 compares the demographic and injury factors for fractures managed with short and long nail.

Table 2. Patient and clinical preoperative characteristics

	Overall (n=65)	Short nail (n=32)	Long nail (n=33)	P value
Age (years)/ Mean (SD)	85.23 (6.31)	87.13 (4.33)	83.39 (7.38)	0.63
Sex				
Female (%)	82	87.5	75.75	0.34
Charlson Index/ Mean (SD)	6.20 (1.91)	6.66 (1.84)	5.76 (1.88)	0.34
AO fracture type				
Type 32 (%)	32.3	13	52	0.01
Type 31 (%)	67.7	87	48	
Parker Mobility Score preop/Mean (SD)	6.14 (2.66)	5.72 (2.79)	6.55 (2.49)	0.16

*Significant values
(SD: Standard deviation)

There was a significant difference in the AO/OTA fracture type between both cohorts. The long nail group included 52% of 32-type fractures whereas we only found a 13% in the short nail group (*P<0.01*).

Attending to the operative and postoperative characteristics, there were not significant differences in the blood transfusion rate, postoperative Parker mobility score, quality of reduction nor complications between both cohorts [Table 3]. There was only one surgical site infection in the short nail cohort. The overall rate of complications was 29.23%, which consisted of seven nonunion, four nail breakages and eight varus deformities [Table 4]. A post-hoc stratification of the two cohorts by AO/OTA fracture type was performed, in order to rule out if this could have acted as a confounding factor. We observed that three out of four patients who underwent a short nail to treat an AO/OTA 32-type fracture suffered a complication, whereas this happened in seven out of 17 cases that underwent a long nail. This difference was not significant either (*P=0.31*) [Figure 3 and Figure 4].

According to the Baumgaertner criteria Table 1, good reduction was achieved in 29.23% patients, acceptable reduction in 47.69% patients and poor reduction in 23.08% patients.

Complication rate was analyzed after segmenting the whole sample by the quality of reduction achieved, as it could also may have had an influence. We found that patients with a good radiological reduction presented no complications. However, those with an acceptable reduction presented a complication rate of 35.5% and this raised to 53.3% in poorly reduced ones (*P=0.002*) [Table 3].

Table 3. Clinical and radiographic postoperative data

	Overall (n=65)	Short nail (n=32)	Long nail (n=33)	P value
Blood transfusion /yes (%)	66.15	65.6	66.66	0.93
Quality reduction				
Good (%)	29.23	21.86	36.36	0.18
Acceptable (%)	47.69	59.37	36.36	
Poor (%)	23.08	18.75	27.27	
Complications/ yes (%)	29.23	31.25	27.27	0.72
Parker Mobility Score postop/ Mean (SD)	-----	3.66 (2.49)	4.82 (3.02)	0.29
Follow-up (days)/ Mean (SD)	-----	450.53 (361.58)	418.58 (252.81)	0.68

*Significant values

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Table 4. Details of all patients who had complications

Sex	Age	Charlson comorbidity index	AO/OTA type	Type of nail	Accuracy of the reduction	Distal locking screw-fracture ldistance	Mechanical complications	Blood transfusion	Surgical site infection	Parker mobility score preoperative	Parker mobility score postoperative	Follow-up (days)
Female	82	8	31.A3	Affixus short nail	Poor	>5cm	nonunion	yes	no	9	3	1795
Male	83	8	31.A3	Affixus short nail	Acceptable	>5cm	varus consolidation	yes	no	9	9	874
Female	87	5	31.A3	Affixus long nail	Poor	>5cm	varus consolidation	yes	no	7	8	302
Female	87	6	32	Affixus long nail	Acceptable	>5cm	varus consolidation	yes	no	8	9	766
Female	80	5	32	Affixus long nail	Acceptable	>5cm	varus consolidation	no	no	3	4	148
Male	77	8	32	Affixus long nail	Acceptable	>5cm	varus consolidation	yes	no	9	9	1228
Female	78	5	31.A3	Affixus long nail	Acceptable	>5cm	nail breakage	yes	no	4	5	935
Female	85	6	32	PFNA short nail	Acceptable	<5cm	nail breakage	yes	no	2	2	673
Female	85	5	32	Affixus long nail	Poor	>5cm	nonunion	yes	no	7	2	585
Female	78	3	32	PFNA short nail	Poor	<5cm	varus consolidation	no	no	7	2	1258
Female	92	6	31.A3	Affixus short nail	Poor	>5cm	varus consolidation	yes	no	3	1	206
Male	95	8	32	PFNA short nail	Acceptable	<5cm	nail breakage	yes	no	4	2	216
Female	87	4	32	Affixus long nail	Poor	>5cm	varus consolidation	yes	no	5	4	416
Female	91	7	32	Affixus long nail	Acceptable	>5cm	nonunion	yes	no	5	4	846
Female	88	6	31.A3	PFNA short nail	Acceptable	<5cm	nonunion	yes	no	2	1	350
Female	89	8	32	Affixus long nail	Poor	>5cm	nonunion	yes	no	7	3	523
Female	88	5	31.A3	PFNA short nail	Poor	<5cm	nonunion	yes	no	7	0	439
Female	91	6	31.A3	Affixus short nail	Acceptable	<5cm	nail breakage	yes	yes	7	3	306
Male	83	4	31.A3	PFNA short nail	Acceptable	<5cm	nonunion	no	no	9	1	250

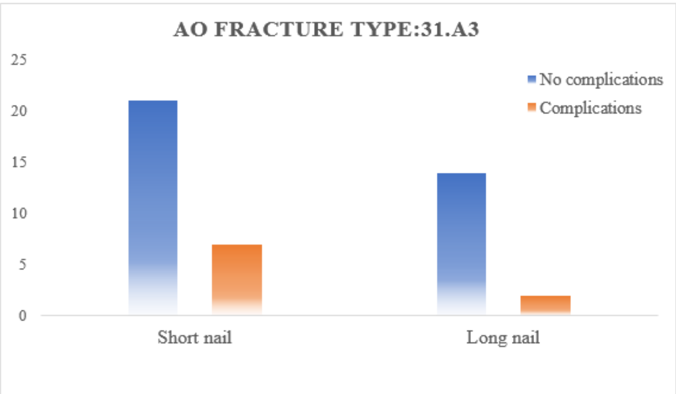

Figure 3. Comparison of number of complications between AO/OTA 31.A3-type fractures treated with short and long nail. P=0.45

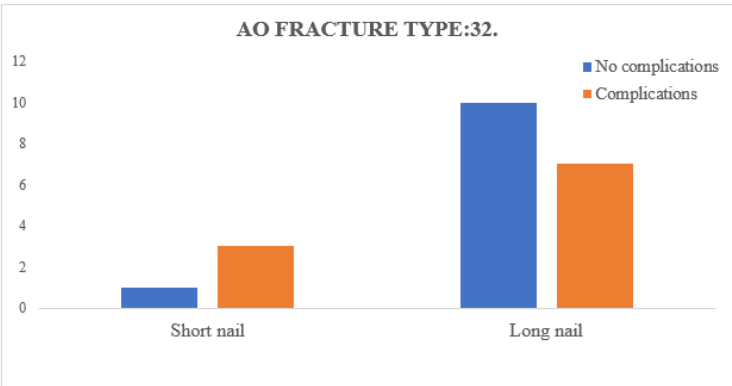

Figure 4. Comparison of number of complications between AO/OTA 32-type fractures treated with short and long nail. P=0.31

There were 12 patients with a distal locking screw-fracture line distance lower than five cm. The presence of complications was analyzed related to this working length. There was a higher complication rate in the <five cm distance group (58.33%) than in the >five cm distance group (22.64%) (*P=0.014*) [Table 5].

Discussion

The treatment of subtrochanteric fractures is challenging. A lack of a universally accepted classification system may complicate the comparison of the results from different studies and establish guidelines for the treatment.[1] The

AO/OTA system was used in this study. This is one of the most commonly used classifications. We included 31.A3 and 32 types that occur within the subtrochanteric area because they share anatomic and biomechanical features.[3,5,16,17]

Table 5. Presence of complications attending to the locking screw-fracture site distance

		Locking screw-Fracture site distance		P value
		<5 cm	*>5cm*	
Complication *(n)*	**None**	5	41	0.014*
	Yes	7	12	
Total		12	53	

*Significant values

Although dynamic hip screw may be used, intramedullary nails are the most commonly used devices due to their biomechanical advantages.[1] there is a lack of consensus concerning the length of the intramedullary nails. Long nails are proposed for unstable fractures.[18] However, evidence suggest that it is not proven their superiority over standard short nails in unstable pertrochanteric fractures (31.A2 and 31.A3 AO/OTA).[17] Okcu found no differences in fixation failure, 1-year-mortality rate, function and union rate between short a and long nails in 31.A3 fractures.[9] As far as we are concerned, this is the first study that compares short and long nails in subtrochanteric fractures. In our study we could not find differences attending postoperative complications between short and long nails. Our overall complications rate was 29.23% which was similar to other published studies.[2,19] The most frequent complication was varus angulation (12,3%), which had been previously described as 14-31%, nonunion and implant failure.[2] [Figure 5 and Figure 6]. If we consider nail breakage as a consequence of nonunion, the nonunion rate was 16, 93%, in agreement with other studies which have described a nonunion risk as high as 20%.[2,19,20]

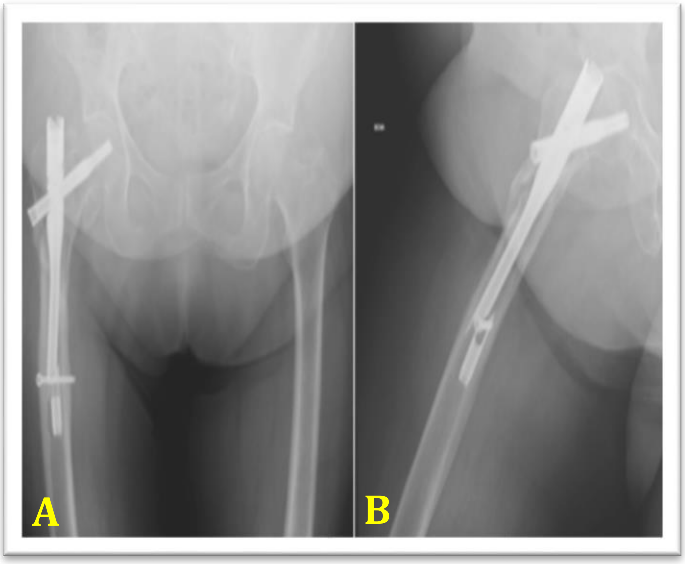

Figure 5. Anteroposterior (A) and lateral (B) radiographs of the right hip at 12-month-follow up show a breakage of the nail at the static locking screw hole

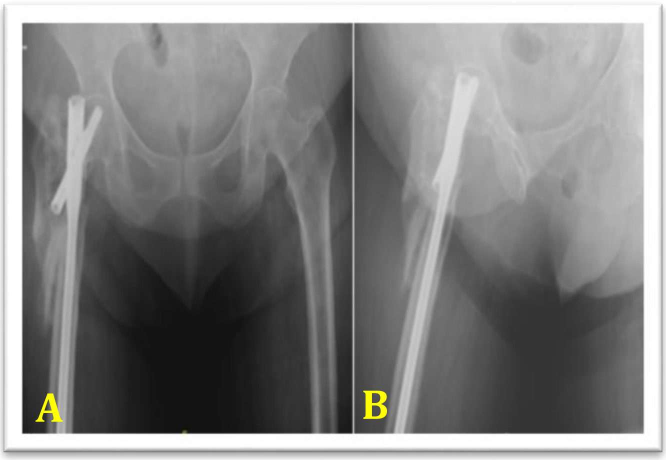

Figure 6. Anteroposterior (A) and lateral (B) radiographs of the right hip at 9-month-follow up show nonunion of the femoral fracture

According to presented data, quality of reduction in subtrochanteric fractures is significatively related to complication rate. This agrees with other studies that consider that malalignment predisposes to malunion, nonunion and implant failure.[2,16,21] High rates of metal fatigue have been reported in fractures fixed with a varus angulation over 10º.[22] There are two systems for assessing the quality of the reduction, the Baumgaertner and the Chang criteria.[15] These both enhance the avoidance of varus malalignment over 10º, angulation over 20º in the sagital X-ray view and the residual displacement for achieving a qood reduction. The main difference is that Chang takes in account the positive medial cortical support. It has been suggested that a good reduction of the fracture is also related to an improved quality of life and social function and to a decreased mortality rate.[21,23,24]

Taking into account previous data, it becomes clear that adequate reduction is the key factor in successful managing of subtrochanteric fractures. If an anatomical reduction is not achieved through closed indirect reduction, open reduction and the usage of clamps and cerclage wires is recommended since it improves the alignment and medial cortical support without impairing the fracture vascular supply and union rate, even in the presence of cerclage wires.[2,16,21]

The working length of an internal fixator is the distance between the first two locking screws located on either side of the fracture site. This is the area to which stresses are applied, it determines the construct's stiffness and may influence fracture healing.[25] As far as we know, there is no consensus concerning the minimum effective distance between the fracture site and the distal locking screw in proximal femoral fractures. It has been suggested a minimum distance of five cm for avoiding complications, so it was chosen as threshold for calculation in the present study.[26] We have found a higher complication rate in the less than five cm distance group than in the over five cm distance group, and this was statistically significant. Our findings were supported by a recent study, which consisted of a finite element analysis that evaluated the stresses around the nail and the cortical bone in subtrochanteric fracture models with short cephalomedullary nails.[8] They concluded that a standard short nail may be suitable for high fragility subtrochanteric fractures, those 10mm-30mm below the lesser trochanter.

We did not find any difference in the postoperative Parker mobility score between short and long nails in subtrochanteric fractures. This was also reported in previous studies that compare short and long nails in unstable pertrochanteric fractures.[18]

Our study showed a higher number of subtrochanteric fractures in women (82%), which is in agreement with previous literature that reported a 33% higher incidence of subtrochanteric fracture in female. Although the reasons are still unclear, it may be related to osteoporosis.[1,7]

Although transfusion requirements do not differ significantly in our study, the surgical blood loss was not assessed and it may be an interesting measure for further studies.

We recognize some limitations in this study. The short number of AO/OTA 32-type fracture treated with a short nail may have underpowered it to detect differences between both cohorts. The retrospective design of the study and the lack of standardized protocols concerning the choice of implant and postoperative weight-bearing may have led to some bias. Finally, even though we defined nonunion as the lack of consolidation of the fracture after nine months, we accepted a minimum follow-up of 3 months. The reason was that we considered it to be the minimum period for detecting consolidation. Among the patients with a follow-up under 9 months we only detected 1 breakage of the nail (216 days of follow-up) and 1 nonunion (250 days of follow-up, which means 20 days left for 9months). All, but those two patients, showed complete fracture healing at their last follow-up visit, which would not have changed at nine months. Complication rate does not seem to be underreported due to this minimum follow-up because it was similar to other published studies.[2,19] Further randomized controlled investigations are required in order to confirm our findings.

Conclusion

We conclude that anatomical reduction may be the key factor in the management of subtrochanteric fractures, in order to avoid complications. The distance between the fracture site and the distal locking screw of the chosen device should also be taken into account to treat these challenging injuries.

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Authors Contribution:
MBAP: conceived of the presented idea, performed data collection, the statistical data analysis and wrote the manuscript.
CP, PV and SM: significantly contributed to data collection.
FBS: aided in data analysis and participated in revising it critically for important intellectual content.
JCA: participated in revising it critically for important intellectual content. All authors gave final approval of the version to be submitted.
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Declaration of Informed Consent: Informed consent was obtained from all patients prior to the surgery. No other informed consent was required due to the retrospective nature of the study. There is no information (names, initials, hospital identification numbers) in the submitted manuscript that can be used to identify patients.

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