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Original Article

Analysis of using antirotational device on cephalomedullary nail for proximal femoral fractures☆,☆☆

Marcelo Itiro Takano, Ramon Candeloro Pedroso de Moraes, Luis Gustavo Morato Pinto de Almeida, Roberto Dantas Queiroz*

Hospital do Servidor Público Estadual de São Paulo, São Paulo, SP, Brazil

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A B S T R A C T

Objective: To analyze the influence of femoral neck diameter in the positioning of the sliding screw in cefalomedulares nails for treatment of unstable transtrochanteric fractures.
Methods: Prospectively throughout 2011, patients with unstable fractures transtrochanteric undergoing osteosynthesis with cephalomedullary nail using antirotacional device. They were evaluated for sex, age and fracture classification according to Tronzo. Through digital radiographs angle reduction, tip apex distance (TAD), stem diameter and measures between the positioning of the screws and the limits of the cervix were measured.
Results: Of the 58 patients, 42 (72.4%) were female and 16 (27.6%) were male. 33 patients were classified as Tronzo III (56.9%), 6 patients as Tronzo IV (10.4%) and 19 as Tronzo V (19.8%). The majority were in between the eighth and ninth decade of life. The average reduction in the angle was 130.05° for females and 129.4° for males. The TAD average was 19.7 mm for females and 21.6 for males. The average diameter of the neck and head vary with statistical significance between men and women. In 19 patients the placement of the sliding bolt can be optimal. If the ideal positioning was not possible, the mean displacement for non-infringement of higher cortical neck was 4.06 mm.
Conclusion: The optimal placement would not be possible for the majority of the population, for the average diameter of the neck of the sample.

Análise do emprego do parafuso antirrotacional nos dispositivos cefalomedulares nas fraturas do fêmur proximal

Palavras-chave:
Fraturas do quadril
Fixação interna de fraturas
Pinos ortopédicos

R E S U M O

Objetivo: analisar a influência do dispositivo antirrotacional no posicionamento do parafuso deslizante das hastes cefalomedulares usadas no tratamento das fraturas transtrocanterianas.

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* *Corresponding author.*
E-mail: ramoncpm@yahoo.com.br (R.C.P. de Moraes).

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Métodos: estudo prospectivo de série de casos composta por 58 pacientes com diagnóstico de fraturas transtrocanterianas instáveis submetidos à osteossíntese com haste cefalomedular dotada de dispositivo antirrotacional. A casuística foi avaliada quanto a sexo, idade e classificação da fratura. Os parâmetros radiográficos avaliados no pós-operatório imediato foram: ângulo de redução, limites anatômicos, distância "ponta-ápice" (TAD), deslocamento do parafuso deslizante em relação ao eixo central do colo femoral e posicionamento do dispositivo antirrotacional.

Resultados: houve preponderância do sexo feminino, com maioria na oitava e nona décadas de vida. Foram classificados como Tronzo III 33 pacientes (56,9%), seis como Tronzo IV (10,4%) e 19 como Tronzo V (19,8%). O ângulo de redução médio no sexo feminino foi 130,5° e 129,4° no masculino. O diâmetro médio do colo e da cabeça variou com significância estatística entre homens e mulheres. O TAD médio foi de 19,7 mm no sexo feminino e 21,6 mm no masculino. Em 10 pacientes (17,85%) o TAD foi superior a 25 mm. Em 19 pacientes (33,9%) a colocação do parafuso deslizante poderia ocorrer no eixo central do colo. O deslocamento médio do implante para não violação da cortical superior do colo foi de 4,06 mm do eixo central.

Conclusão: no implante estudado, dotado de dispositivo antirrotacional, o posicionamento do parafuso deslizante no eixo central do colo está condicionado a diâmetro mínimo de 34 mm do colo femoral.

Introduction

The transtrochanteric fractures correspond to extracapsular fractures of the proximal femur included between the greater and lesser trochanters.[1,2] Of the annual 250,000 proximal femoral fractures in the U.S.A., 25% are transtrochanteric.[3,4] Each year, in developed countries this lesion affects one in every 1000 people. It is estimated that in 2050 the incidence will be three times higher[3,5] and the annual cost of US$ 8 billion will be duplicated.[3,6] Thus, worldwide these fractures are considered as a major public health problem.[1,2]

These are the most frequent fractures, with higher associated mortality rate (12–41% in the first six months),[7] and 90% of them, arising from low-energy trauma, occur in patients older than 65 years.[8]

Usually, the treatment is surgical. Only exceptionally the procedure will be conservative in patients with comorbidities that contraindicate anesthesia, surgery, or both.[1,8,9] It is essential that the stability of the fracture be determined, so that the surgeon can properly choose the method to be employed. Unstable fractures are those lesions involving the posterior-medial cortex and that feature reverse trace or subtrochanteric extension.[1,8] Recently, the critical importance of the lateral cortex in regional stability was recognized.[10–13]

In stable fractures, the implant of choice is the sliding hip screw (DHS); however, because of the biomechanical advantages of intramedullary location, cephalomedullary implants have been advocated for the treatment of unstable fractures.[1,14–17]

Both for DHS and for cephalomedullary pins, placing the sliding screw in the correct position is crucial to the success of osteosynthesis. The method of Baumgartner corresponds to the parameter of good positioning currently more accepted.[1] Anatomical characteristics of certain populations and factors related to the experience of the surgeon were related to a placement not always considered "ideal" for these implants.[18–20]

In the evolution process of cephalomedullary pins, the anti-rotational device evolved in order to provide additional stability to the system, both at the time of its implementation and in maintaining the reduction until the consolidation. However, the presence of an anti-rotational device is related to early complications arising from its position, and later, like as a "Z effect."[1,21]

The present study aimed to analyze the influence of the use of anti-rotational device in cephalomedullary pins used in our institution in the average displacement of the sliding screw in its positioning along the central axis of the femoral neck. Furthermore, our study aims to determine the percentage of patients whose tip-apex distance was beyond the recommended measure, and the relation of minimum diameter of femoral neck for implant positioning.

Materials and methods

The study was submitted to and approved by the Ethics and Research Committee of Hospital do Servidor Público Estadual de São Paulo (HSPE). All patients signed an informed consent to participate.

From January to December 2011, a case series comprised of 58 patients admitted to the emergency room of the HSPE with preoperative radiographic diagnosis of unstable proximal femur fracture was prospectively analyzed. The participants were evaluated for age, gender, and fracture classification. According to the classification of Tronzo,[13] fractures type III, variant III, IV and V (Fig. 1) were considered unstable. In the osteosynthesis, we employed the principle of relative stability, with the cephalomedullary tutor used in our institution. The surgical technique was common to all patients and consisted of an indirect reduction of the fracture and osteosynthesis in

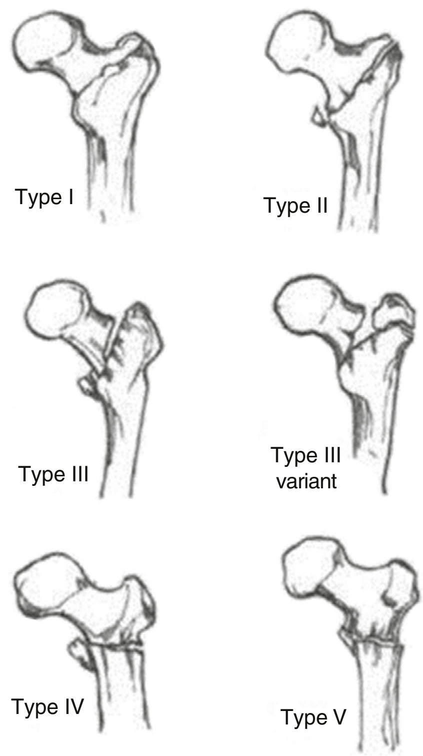

Fig. 1 – Tronzo's classification.

orthopedic table by the closed focus technique, with the aid of fluoroscopy.

We used pins with a distal diameter of 10 or 12 mm and with a single proximal diameter of 17 mm, mediolateral angle of 6° and cervicodiaphyseal angle of 130° between the neck and the intramedullary nail screws. The choice of implant was taken after preoperative planning, according to the cervicodiaphyseal angle of the proximal end of the contralateral femur and the diameter of the medullary diaphyseal region. All patients received antithrombotic and antibiotic prophylaxis.

Two cases were excluded because, during the operation, it was decided not to use the anti-rotational device. These patients were considered only in the assessment of gender, age and Tronzo's classification.

In the immediate post-operative period, plain digital radiographies (anteroposterior [AP] and profile [P] views) of the pelvis and of the hip ipsilateral to the osteosynthesis were obtained, according to the standardization proposed by Polesello et al.[22] In AP view, the patient was positioned supine with the legs in internal rotation of 15–20° and with the beam of X-rays directed at the midline just above the pubic symphysis. In Acelin's profile view, the patient was positioned supine with 90° of flexion of the contralateral hip, with the X-ray tube angled at 45° cranially in the horizontal plane, toward the root of the affected thigh (Fig. 2).

With the use of filing and transmission system Impax® (version 6.3.1.7501, AGFA Health Care NV), the measures (in millimeters) of the diameter of the femoral head at its greatest axis, diameter of the neck in its smaller thickness (AB), angle of reduction, distance between the center of the sliding screw and the top edge of the anti-rotational device (ZX), and distance from the center of the sliding screw to the inferior margin of the neck (XB) were digitally obtained in the AP position. The central axis of the neck was determined using the midpoint of the smaller thickness of the femoral neck (AB).

The distance from the tip of the screw to the apex of the femoral head was assessed in AP and P (Tip Apex Distance, TAD) views, according to Baumgartner and Solbert method. Fig. 3 shows schematically the points of reference used for these measurements, and Fig. 4 demonstrates the use of digital tools of the Impax® program for obtaining the aforementioned measures.

The value of ZX (15 mm) is constant and supplied by the manufacturer. Such information was confirmed in an implant sample with the use of a universal caliper (Fig. 5). To ensure reliability of the data obtained, we applied as individual correction factor for each measurement made the relation of the measurement of ZX obtained on the digital radiography versus value provided by the manufacturer.

Considering as ideal the positioning of the sliding screw on the central axis of the neck, we examined the feasibility of this positioning in our sample with the analysis of the minimum neck diameter required and its relation to the size of ZX. Then, we attributed the minimum distance of 2 mm from each

Fig. 2 – Standard positioning for AP and P radiographs.

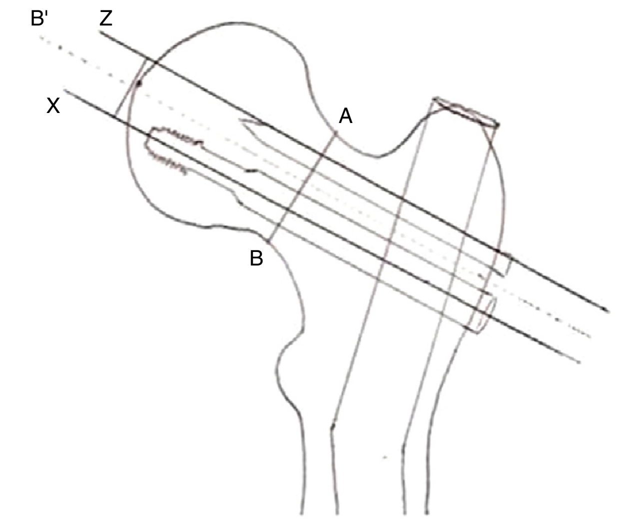

Fig. 3 – Reference points for the proposed measures. AB: diameter of the femoral neck in its smaller thickness. AB′: radius of the femoral neck. X: axis of sliding screw. Z: line tangent to the upper edge of the anti-rotational device. ZX: distance from the axis of the screw to the upper edge of the anti-rotational device.

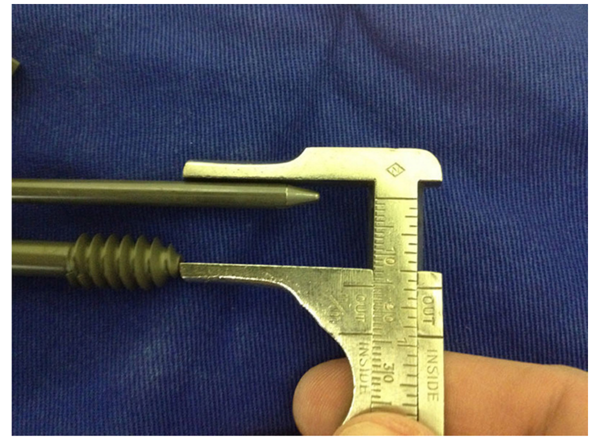

Fig. 5 – True measure of distance ZX, with universal caliper.

osseous margin and determined the equation: AB = (ZX + 2) 2. As the value of ZX corresponds to 15 mm, the minimum size of the femoral neck for such positioning is 34 mm. Then, we calculated the percentage of the sample in which the positioning here considered as ideal could be obtained.

We measured the average separation of the sliding screw in relation to the central axis of the neck in situations where an optimum positioning cannot be achieved.

The analyses of the quantitative variables were evaluated statistically with respect to the mean, median, standard

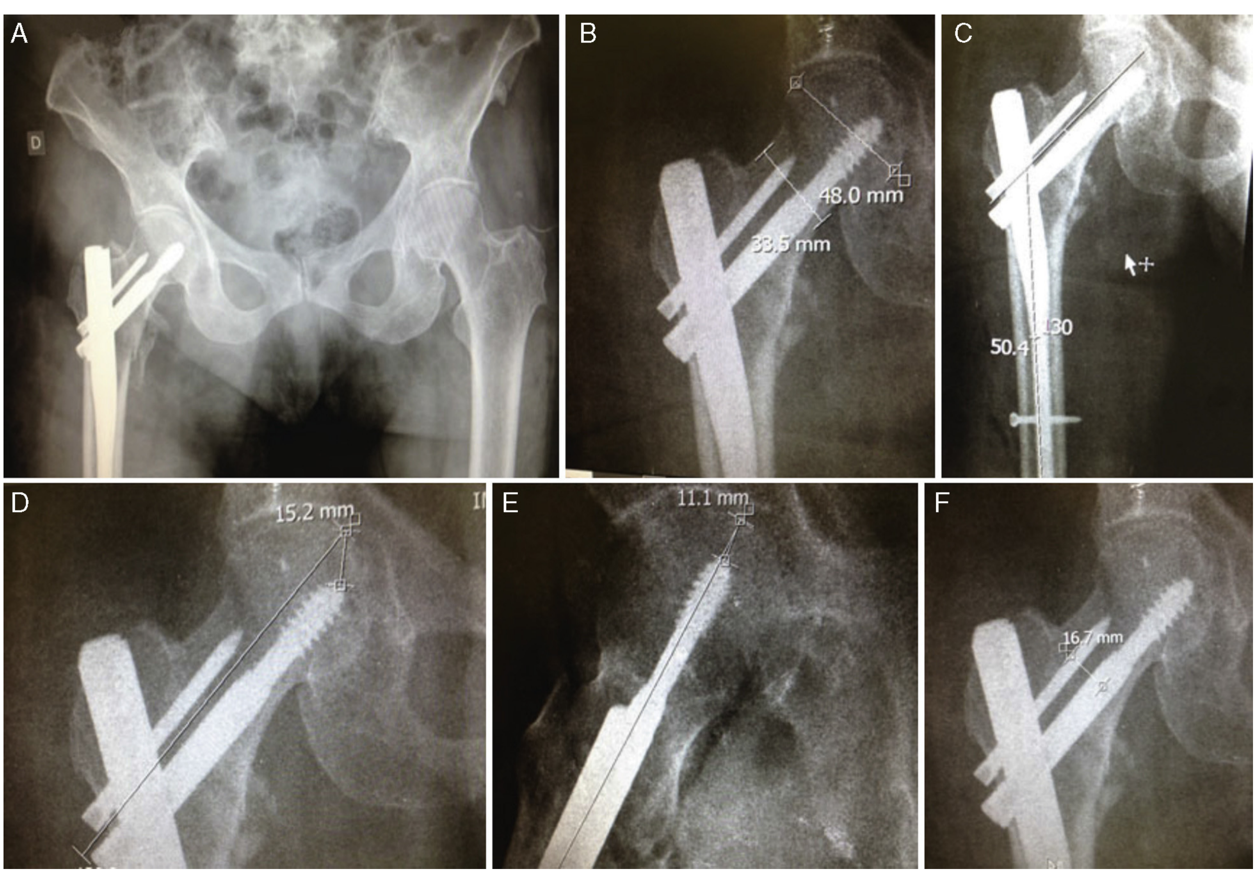

Fig. 4 – Use of Impax® for the taking of measures. (A) AP radiograph of the pelvis, as described. (B) Diameter of the neck and head. (C) Angle of reduction. (D) TAD in AP. (E) TAD in PF. (F) Distance ZX.

Table 1 – Age distribution by gender.

Gender	Mean	Median	Standard deviation	Minimum	Maximum	P value
Age						
F	81.83	84.00	10.23	48.00	97.00	0.0743
M	77.07	77.00	6.23	68.00	90.00	

Table 2 – Association between gender and Tronzo's classification ($P = 0.7744$).

Tronzo	Gender				Total	
	F		M		N	%
	N	%	N	%		
III	24	57.1	9	56.3	33	56.9
IV	5	11.9	1	6.3	6	10.3
V	13	31.0	6	37.5	19	32.8
Total	42	100.0	16	100.0	58	100.0

Table 3 – Intraoperative parameters related to the reduction and implant positioning.

Gender	Mean	Median	Standard deviation	Minimum	Maximum	P value
Angle of reduction (AP)						
F	130.05	132.00	10.42	108.00	158.00	0.8755
M	129.40	131.00	9.81	108.00	144.00	
TAD						
F	19.70	20.10	6.82	1.90	38.50	0.2401
M	21.67	21.90	6.82	2.40	30.00	

deviation, minimum, and maximum. In the comparison between the genders, we applied the nonparametric Wilcoxon test. The qualitative variables were evaluated for distribution of absolute and relative frequencies, and their associations were tested by Pearson Chi-square test or Fisher exact test, when the approximation of the first test was not appropriate. The significance level used in these tests was 5%, and optional two-tailed hypotheses always were considered.

Results

Of the 58 patients in the series, 42 (72.4%) were women and 16 (27.6%) men. In the analysis of the age distribution, most of the study patients were between the eighth and ninth decades of life, and there was no statistically significant difference in the comparison between genders (Table 1).

Regarding the classification of the fracture and according to Table 2, 33 (56.9%) patients were grouped as Tronzo III, six (10.4%) as Tronzo IV, and 19 (19.8%) as Tronzo V. The associative analysis between Tronzo's classification and gender revealed no statistically significant difference.

With the help of standard X-rays, we obtained data concerning the angle of reduction achieved during the intra-operatory period and the implant positioning; no statistical significance was demonstrated when comparing gender, according to Table 3.

Regarding the TAD, it was observed that in 46 cases (82.15%) the values were smaller than 25 mm, thus being considered ideal.

A comparison of neck and head diameter values of the selected patients showed statistically significant differences between genders, which also occurred for the measure of Z_X (Table 4).

Table 4 – Diameter of femoral head and neck obtained according to gender.

Gender	Mean	Median	Standard deviation	Minimum	Maximum	P value
Head (AP)						
F	49.41	50.00	3.04	43.80	55.10	0.0084
M	53.05	54.40	4.45	43.60	58.80	
Neck (AB)						
F	34.69	34.30	2.99	28.90	41.80	0.0086
M	37.23	38.00	4.19	26.70	43.10	
Z_X (implant)						
F	16.75	16.80	1.85	11.90	22.00	0.0192
M	15.42	15.50	1.65	11.60	17.70	

Table 5 – Spreadsheet with values obtained after applying the individual correction of measurement factor.

Nr.	Age	Gender	AB	θ reduction	AB′	Z_X	Correction factor	TAD	Tronzo	Neck
1	85	F	42	139	20.9	22	1.466666667	17.9	V	28.5
2	78	F	33	121	16.5	20.5	1.366666667	20.1	III	24.07
3	74	F	31	147	15.3	20.6	1.373333333	13.3	III	22.28
4	48	F	35	158	17.5	17.1	1.14	12.6	III	30.61
5	89	F	36	141	18	15.8	1.053333333	20.2	III	34.08
6	97	F	35	140	17.7	15.3	1.02	18.6	III	34.7
7	70	F	33	141	16.6	17.2	1.146666667	20.3	V	23.09
8	77	M	43	142	21.6	15.2	1.013333333	19.7	V	42.53
9	79	F	35	136	17.7	16.1	1.073333333	19.7	V	31.21
10	89	F	33	131	16.7	15.4	1.026666667	18.6	V	32.53
11	78	M	35	144	17.3	12.8	0.853333333	16.2	V	40.54
12	94	F	34	117	16.8	17.5	1.166666667	12.2	III	28.71
13	92	F	40	115	20	16	1.066666667	11	III	37.5
14	90	M	40	131	19.8	16.5	1.1	24.8	V	35.9
15	80	F	41	135	20.5	18	1.2	23	V	34.16
16	85	F	36	115	17.9	20.8	1.386666667	22.5	III	25.74
17	92	F	37	136	18.6	17.5	1.166666667	17.6	IV	31.81
18	79	F	37	140	18.7	16.7	1.113333333	22	IV	33.59
19	92	F	32	108	15.8	16.8	1.12	22	III	28.12
20	74	F	35	125	17.5	18	1.2	26	V	29.16
21	93	F	39	133	19.4	11.9	0.793333333	21	III	27.54
22	87	F	30	125	15.1	15.3	1.02	29.1	III	30
23	73	F	30	110	15.2		0	28.3	IV	Excluded
24	63	F	29	122	14.5	17.8	1.186666667	15.4	III	24.35
25	69	M	41	123	20.7	17	1.133333333	26.3	IV	36.52
26	79	M	42	119	20.8	15.1	1.006666667	30	III	41.32
27	80	F	39	143	19.3	15.4	1.026666667	20.1	III	37.59
28	86	F	34	130	17.2	17.4	1.16	25.3	IV	29.65
29	75	M	38	127	19	15.5	1.033333333	24.7	III	36.67
30	90	F	38	126	18.8	17.4	1.16	29.3	III	32.41
31	64	F	33	132	16.3	13.9	0.926666667	16.3	III	34.74
32	92	F	37	119	18.3	17.2	1.146666667	29	III	31.83
33	84	F	33	139	16.7	16	1.066666667	15.3	III	31.31
34	91	F	31	113	15.3	16.3	1.086666667	19.5	III	28.06
35	77	F	30	135	14.8	15	1	14.1	V	29.6
36	87	F	33	121	16.5	15.5	1.033333333	17	III	31.93
37	77	M	38	120	19.2	17	1.133333333	20.1	V	33.79
38	86	F	36	122	17.8	15.2	1.013333333	23.2	V	35.03
39	66	F	33	137	16.5	14.9	0.993333333	30	IV	33.12
40	72	M	37	128	18.6	11.6	0.773333333	21.9	III	47.97
41	76	M	39	134	19.5	17.7	1.18	2.4	III	33.05
42	74	F	34	135	16.9	16.5	1.1	24.6	V	30.72
43	70	M	39	134	19.7	14.7	0.98	28.4	III	40.1
44	95	F	34	123	17.2	17.5	1.166666667	1.9	V	29.4
45	90	F	34	127	16.9	16.8	1.12	16.9	III	30.08
46	81	F	33	116	16.7	16.9	1.126666667	23.2	III	29.64
47	68	M	35	134	17.7	14.6	0.973333333	21	III	36.26
48	73	F	37	125	18.7	16.9	1.126666667	13	V	33.19
49	82	M	31	132	15.7	15.8	1.053333333	17.5	V	28.71
50	78	F	33	133	16.5	16.1	1.073333333	38.5	V	30.74
51	90	M	35	124	17.4		0	20.1	III	Excluded
52	75	M	27	108	13.4	17.1	1.14	28.9	V	23.42
53	85	F	32	132	16	15.3	1.02	20.3	III	31.37
54	87	M	35	123	17.7	16.1	1.073333333	18.6	III	32.88
55	84	F	37	125	18.4	16.8	1.12	24	III	32.76
56	72	F	37	136	18.7	15.8	1.053333333	20	III	35.5
57	81	M	38	142	19	14.6	0.973333333	24.5	III	39.04
58	80	F	34	138	16.8	17.8	1.186666667	32	V	28.23

Applying the correction factor for each individual measurement, values taken as real were obtained. These values are shown in Table 5.

Given the corrected diameter of the femoral neck, it was found that an ideal positioning would be possible in 19 patients with CI (95%) = 21.8%; 47.8% (Table 6).

For those cases in which the position of the sliding screw could not be ideal, the mean inferior separation value (XB) found with relation to the central axis was 4.06 (Table 7).

Table 6 – Percentage of patients whose placement of the system could be ideal.

Ideal possible?	Nr.	%	% valid
Not	37	63.8	66.1
Yes	19	32.8	33.9
Total	56	96.6	100.0
Excluded	2	3.4	
Total	58	100.0	

Discussion

The treatment of unstable transtrochanteric fractures with use of cephalomedullary pins presents biomechanical advantages due to its intramedullary location, such as reducing the bending moment, better rotational control, shortening, and collapse in varus.[1,14–17] Although controversial, there are reports of superiority of cephalomedullary pins versus DHS in relation to early return to ambulation, reduced surgical time, and less blood loss.[1,8,19] Thus, at our institution cephalomedullary pins are applied in the treatment of unstable fractures.[1]

Regarding the epidemiological findings observed in the present study, there is a vast literature attesting the female predominance and an age close to 80 years in other series.[1,9,18,21,23] This reflects the decrease in bone mineral density. We found no statistically significant difference between the ages of male and female patients.

Although the pattern fracture of reverse obliquity (Tronzo V or AO 31 A3) has been reported as the most frequent type in some case series of unstable fractures,[9,24] most studies have described as the most prevalent types those classified as Tronzo III or IV (or AO 31 A2),[1,18,25,26] which agrees with our results. When comparing males and females, we found no statistically significant differences in relation to fracture type according to the classification of Tronzo.

According to Werner-Tutschku et al.,[27] the main predictor of the cutout is unsatisfactory initial reduction, especially in varus, besides favoring Trendelenburg gait.

We found a mean value of 130.5° for men (with a standard deviation of 10.42) and 129.40° (9.81) for women, and this assessment was not statistically significant. These findings are similar to those found in another study with unstable transtrochanteric fractures.[1]

There was a statistically significant difference in the comparison between male and female genders in the measurements related to diameter of the head and neck. When comparing the bone structure of the neck in young and elderly subjects of Chinese and Caucasian origin, Wang et al.[28] showed that male subjects have larger diameters, that this value tends to increase with age, being higher in populations of white origin. According to Pu et al.,[18] as the Chinese population is of lower stature than that of the European subjects, the length of the proximal femur and the diameter of the femoral neck are also smaller, which leads to the inappropriate positioning of the cephalomedullary pin's spiral blade used in the study, or to redundancy of the proximal end of the pin. In the utilization of the cephalomedullary pin used in our service, the minimum diameter for an optimal placement is 34 mm, which corresponds to twice the Z_X measure, taking into account a thickness of cortical (top and bottom) of 4 mm. In our series, in only 19 patients (32.8%) the placement of the sliding screw could be performed in the situation regarded as ideal by our methodology. Extrapolating the confidence interval for the Brazilian population, only in 21.8–47.8% of patients in 95% of the time the implant could be placed optimally (i.e., the center of the sliding screw located along the central axis of the neck).

According to Baumgaertner et al.,[15] the correct implant placement occurs when the distance between the tip of the sliding screw and the femoral head center does not exceed 25 mm after the sum of the values obtained on anteroposterior and profile views (tip-apex index, or TAD <25 mm). This facilitates the telescoping of the dynamic system of the implant and reduces the risk of cutout.[9] Although described for osteosynthesis with DHS, the method can be used to assess the correct positioning of the cephalomedullary pins.[1] However, in pins with two proximal fixation screws, there is difficulty in the positioning of the sliding screw in the center of the femoral head in the anteroposterior view. Thus, there is a greater tendency for the positioning of the sliding screw in a more inferior location in the AP radiographic view, particularly in patients with short femoral neck and head.[21] The location of the screws in the profile position is not affected, since the screws are parallel. In the osteosynthesis using the cephalomedullary pin in question, the mean displacement necessary for the introduction of the nail without violating the anti-rotational upper cortical neck was of 4.6 mm (i.e., the amount of downward displacement of the system, in millimeters, from the axis of the femoral neck). To calculate the required displacement of the sliding screw relative the central axis of the neck in situations where this option is not possible, the following formula: = displacement required = 34 mm − neck size (AB) was applied.

Conclusion

Considering the mean diameter of the neck in our sample, the positioning on the central axis of the neck would not be possible for the majority of the population.

Considering the implant studied, the minimum size of the neck which allows positioning the central axis is 34 mm.

Table 7 – Displacement of the system in relation to the central axis.

	Mean	Standard deviation	CI (95%)		Median	Q25	Q75	Minimum	Maximum
			Inf. thres.	Sup. thres.					
Neck corrected	4.06	2.95	3.07	5.04	3.91	1.59	5.29	0.21	11.72

In situations where the positioning in the central axis is not possible due to the minimal size of the neck, the downward displacement required can be calculated by the formula: displacement required = 34 − neck size (AB).

Conflicts of interest

The authors declare no conflicts of interest.

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