Cerclage Wiring in Subtrochanteric Hip Fractures. Analysis of Benefits and Complications

Germán Garabano, Alan Gessara, Joaquín Rodríguez, Tamara Dainotto, Hernán del Sel
Orthopedics and Traumatology Service, Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina

ABSTRACT

Background: The aim of this retrospective study was to assess whether open reduction with cerclage wire affected the union and/or complication rate in subtrochanteric hip fractures treated with cephalomedullary nails. **Materials and Methods:** We analyzed all patients who had undergone surgery in our center between January 2010 and December 2017. We comparatively analyzed those treated with (Group A) and without (Group B) cerclage wire in terms of fracture type, hospital stay, surgical time, blood transfusions, malalignment, union, and complications (infection rates, non-union, and reoperations). **Results:** Fifty-eight patients were included. Group A consisted of 20 patients and Group B of 38. The most frequent type of fracture was 3A (p 0.0004). The mean hospital stay was similar (9 vs 10.6 days p 0.81), the surgical time and transfusions were higher in group A (p<0.0001 and p 0.58 respectively). The union rate was similar (90 vs 92.1%;p 0.09, respectively). Malalignment was only observed in group B (5 - 13.5%; p 0.01). The complication (15 vs 18.4%) and reoperation (15 vs 15.8%) rates were similar (p 0.99). **Conclusions:** The use of cerclage wire in subtrochanteric hip fractures treated with cephalomedullary nails generated a significant increase in surgical time and a lower rate of malalignment. It allowed a lower rate of re-operation, although it was not significant.

Key words: Subtrochanteric fracture; cerclage wire; union; nonunion; infection; malalignment.
Level of Evidence: III

Cerclaje con alambre en fracturas subtrocantéricas de cadera. Análisis de beneficios y complicaciones

RESUMEN

Introducción: El objetivo de este estudio retrospectivo fue evaluar si la reducción abierta con cerclaje de alambre afectó la consolidación, la tasa de complicaciones y de reoperaciones en pacientes con fracturas subtrocantéricas de cadera, tratadas con clavos cefalomedulares. **Materiales y Métodos:** Se evaluó a todos los pacientes operados consecutivamente entre enero de 2010 y diciembre de 2017. Se comparó a los tratados con cerclaje (Grupo A) o sin cerclaje (Grupo B) de alambre en términos de tipo de fractura, estancia hospitalaria, tiempo quirúrgico, necesidad de transfusiones, calidad de la reducción, consolidación y complicaciones (infección, seudoartrosis, reoperaciones). **Resultados:** Se incluyó a 58 pacientes. El grupo A estaba conformado por 20 pacientes y el grupo B, por 38. El tipo de fractura más frecuente fue 3A (p = 0,0004). La estancia hospitalaria fue similar (9.0 vs. 10.6 días; p = 0,81), el tiempo quirúrgico y la necesidad de transfusiones fue mayor en el grupo A (p <0,0001 y p = 0,58, respectivamente). La tasa de consolidación fue similar en ambos grupos (90 vs. 92,1%, respectivamente; p = 0,09). Los desejes se observaron solo en el grupo tratado sin lazadas (5-13,5%; p = 0,01). Las tasas de complicaciones (15 vs. 18,4%) y de reoperaciones (15 vs. 15,8%) fueron similares (p = 0,99). **Conclusiones:** El uso de lazadas de alambre en fracturas subtrocantéricas de cadera tratadas con clavos cefalomedulares generó un aumento significativo del tiempo quirúrgico, y disminuyó significativamente la incidencia de desejes. La incidencia de reoperaciones fue menor, aunque no significativamente.

Palabras clave: Fractura subtrocantérica; lazada de alambre; consolidación; seudoartrosis; infección; desejes.
Nivel de Evidencia: III

Received on June 24th, 2021. Accepted after evaluation on July 17th, 2021 • Dr. GERMÁN GARABANO • ggarabano@gmail.com http://orcid.org/0000-0001-5936-0607

How to cite this article: Garabano G, Gessara A, Rodríguez J, Dainotto T, del Sel H. Cerclage Wiring in Subtrochanteric Hip Fractures. Analysis of Benefits and Complications. *Rev Asoc Argent Ortop Traumatol* 2022;87(2):143-151. https://doi.org/10.15417/issn.1852-7434.2022.87.2.1400

INTRODUCTION

Subtrochanteric fractures represent between 4% and 19% of fractures of the proximal femur.[1,2] The muscular insertions of this anatomical region cause these fractures to present with deformities in flexion, external rotation, and abduction.

The compression and tension forces of the proximal femur require an adequate osteosynthesis that provides relative stability in search of consolidation. The treatment of choice is locking cephalomedullary nailing, which achieves a reported healing rate of up to 95%.[2-4]

The use of a traction table and, on some occasions, of elements such as levers, pins, reduction forceps, facilitates the adequate alignment of these fractures.[4-8] However, in certain fracture patterns, manipulation and closed reduction do not achieve correct alignment, and require the opening of the focus and the use of cerclage wire in 7-40% of cases, according to the literature.[2-6]

Due to the loss of the fracture hematoma and the theoretical damage to the periosteal vascularization, some authors try to avoid its use.[9-11] Perren[9] maintains that biological fixation is the ideal treatment for these fractures and that the periosteal vascularization should not be affected with open reductions or cerclage wire.

The objective of this retrospective study was to evaluate whether open reduction with cerclage wire affected union rates, complications, and reoperations in patients with subtrochanteric hip fractures treated with cephalomedullary nails.

MATERIALS AND METHODS

Between January 2010 and December 2017, 75 consecutive subtrochanteric hip fractures were treated at our center. The identification of the patients was carried out through a search in the database of our service, where each operated patient is systematically registered and the information on their evolution is collected prospectively. This study was conducted after approval by the Institutional Review and Ethics Committee of our institution.

The inclusion criteria were: patients >18 years old, subtrochanteric fracture, treatment with cephalomedullary nail, use or not of cerclage wire, minimum follow-up of 12 months.

The exclusion criteria were: fractures caused by tumor processes, fractures related to the use of bisphosphonates, and those derived from another center with some type of previous treatment.

All patients underwent surgery in the same center, by the same surgical team, on a traction table under fluoroscopy. Initially, closed reduction of the fracture was always attempted. When it was not possible, the focus was opened with careful management of soft tissues and then the fracture was directly reduced and cerclage wire was placed (Figure 1). 1.5 mm diameter wires were always used.

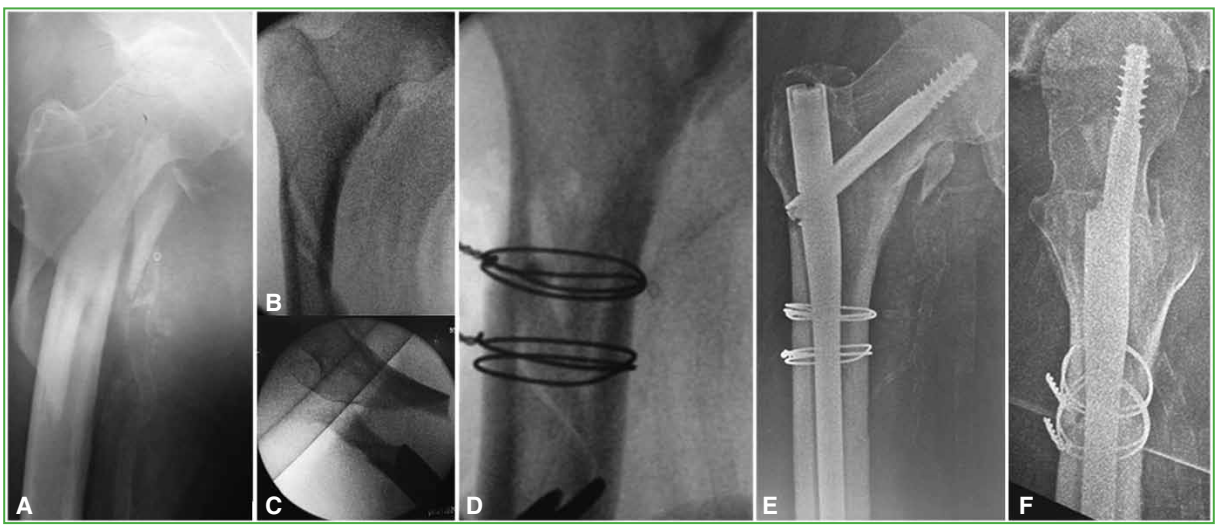

Figure 1. A. Anteroposterior radiograph of the right proximal femur. A 3A subtrochanteric fracture is observed. Intraoperative radioscopy. **B.** Anteroposterior view showing acceptable alignment. **C.** With the same reduction of image A, but in the lateral view, where a significant misalignment is observed. **D.** Reduction with cerclage wire. **E and F.** Anteroposterior and lateral radiographs of the right proximal femur in the postoperative control, where consolidation can be observed.

Postoperative rehabilitation consisted of progressive weight bearing with a walker or Canadian crutches from the second day after the operation. Clinical-radiological controls were performed at 3 and 6 weeks, and at 3, 6, and 12 months depending on the evolution of each case.

The variables analyzed were sex, age, mechanism of injury (high or low energy), type of fracture according to the Seinsheimer classification,[12] surgical time, quality of reduction, tip-apex distance, days of hospitalization, need for blood transfusions, rate and time of consolidation, any type of complication and reoperation.

On the immediate postoperative radiograph, the quality of the reduction and the tip-apex distance were assessed. The quality of the reduction was evaluated by determining the cervico-diaphyseal angle of the operated femur and the contralateral femur, evaluating the existence of angulations in both anteroposterior and lateral radiographs. Reduction was considered good when this measurement presented a comparative misalignment with the non-operated limb <10º in the anteroposterior and lateral projections; acceptable when the misalignment was observed in one of the two projections; and poor when it was observed in both projections. A rotational misalignment of ≥4° was considered poor reduction.

The tip-apex distance was measured using the method described by Baumgaertner, and a value of ≤25mm was considered correct.[13]

Through the analysis of the successive radiographic controls, the rate and time of consolidation, and the development of any type of complication were evaluated.

In the clinical-radiographic evaluation, the fracture was considered to be consolidated if there was no pain on weight-bearing and the bone callus was observed in three of the four cortices, in the two projections (anteroposterior and lateral of the femur).

Pseudarthrosis was defined as the absence of consolidation nine months after surgery, with no progress in healing in the last three months.

For the objective analysis of function, the Harris hip score recorded at the last office follow-up was used.[14]

The results were generally evaluated for each variable and then comparatively analyzed by dividing the patients into two groups: group A, with cerclage wire, and group B, without cerclage wire.

Statistical analysis

The categorical variables were summarized with frequency and percentages. To analyze the association between the categorical variables, the chi-square or Fisher test was used when the assumptions were not verified. Continuous variables were summarized as mean and standard deviation when there were no atypical values and as median and range or interquartile range when it was more appropriate according to their distribution; they were compared between groups with the Wilcoxon test. The analysis was performed with the R program and the conclusions were drawn with a significant p value <0.05.

RESULTS

Seventeen of the 75 patients analyzed were excluded: nine because they had been treated at another Center at the time of referral, three for fractures associated with bisphosphonates, three for fractures secondary to tumor processes, and two for not complying with the minimum follow-up.

The series consisted of 58 patients with 58 subtrochanteric fractures, 35 (60.3%) were women. The mean age was 68.34 ± 22.06 years. The mechanism of injury was low energy in 39 (67.2%) cases and high energy in 19 (32.8%).

According to the Seinsheimer classification, the most frequent fracture pattern was subtype 3A (36%), followed by subtype 2B (22%), type 5 (16%), type 4 (9%), subtype 3B (7%), subtype 2C (7%), 2A (3%).

In 38 (65.5%) patients, the fracture reduction was closed and, in 20 (34.5%), open; wiring was used in all cases: one loop in eight patients and two loops in 12 patients. The fracture subtype in which wiring was used the most was 3A (52.38%, p = 0.004).

The implants used were: 28 PFN® (Depuy Synthes, WA Ind, USA), 16 Galileo TNS® (AOS, TO CA, USA), nine Gamma II® (Stryker, WA Ind, USA), five ITST® (Zimmer, WA Ind, USA).

The comparative characteristics regarding sex, age, and type of fracture of each group are detailed in Table 1.

Table 1. Preoperative characteristics of each group

	Group A (with cerclage wire) (n = 20)	Group B (no cerclage wire) (n = 38)	p
Female sex (%)	70	55.3	0.41
Age	75.3 ± 17.3	64.7 ± 23.5	0.07
Type of fracture (n %)			
2A	1 - 5	1 - 2.6	0.90
2B	2 - 10	11 - 28.9	0.18
2C	0	4 - 10.5	0.28
3A	11 - 55	10 - 26.3	0.004
3B	3 - 15	1 - 2.6	0.11
4	1- 5	4 - 10.5	0.65
5	2 - 10	7 - 18.4	0.47

The surgical time was 69.19 ± 8.34 min, the transfusion rate was 43.1%, and the median hospital stay in the series was 9 days (range 6-50).

The group treated with cerclage wire required fewer hospital days, more surgical time (Figure 2), and more postoperative red blood cell transfusions than the group treated without cerclage wire (Table 2).

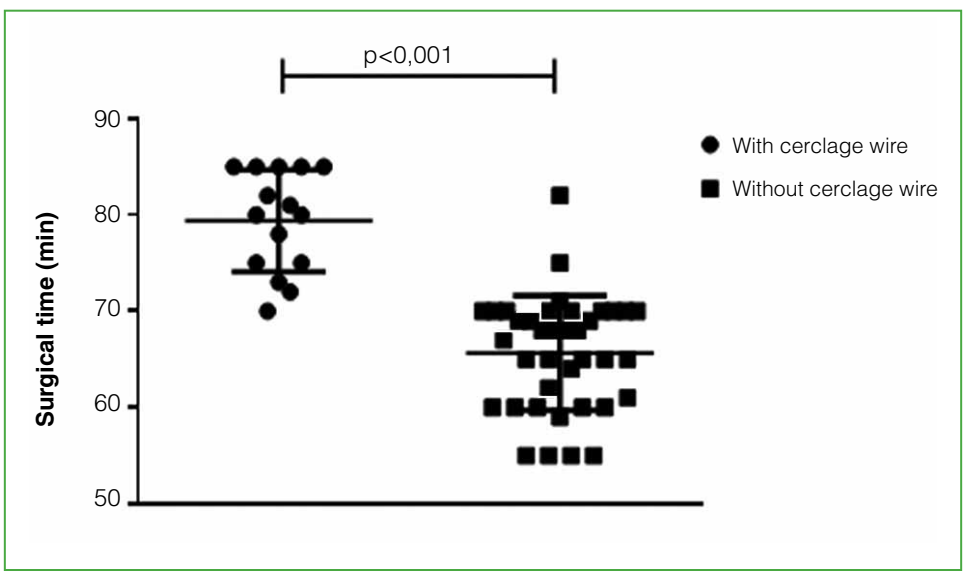

Figure 2. Distribution and significant difference regarding surgical time between groups.

Table 2. Comparative results between the groups with cerclage wire and without cerclage wire.

	Group A (with cerclage wire) (n = 20)	Group B (no cerclage wire) (n = 38)	p
Hospital stay (days) (median IQR)	9 (3-18)	10 (3-22)	0.81
Surgical time (min) (mean SD)	75.2 ± 9.05	66.03 ± 5.94	<0.0001
Transfusions (n %)	10 - 50	15 – 39,8	0.58
Reduction (n %) Good Acceptable Fair	 20 -100 0 0	 33 - 86.8 3 - 7.8 2 - 5.3	0.46
TAD (mm) (mean SD)	14.8 ± 4	15.8 ± 3.6	0.23
Misalignment (n %)	---	5 – 13.5	0.01
Consolidation (n %)	18 - 90	35 – 92.1	0.9
Consolidation time (weeks)	15.1	15.2	0.21
HHS (mean SD)	89.8 ± 2.05	87.9 ± 3.75	0.11

IQR = interquartile range, SD = standard deviation, HHS = Hip Harris Score, TAD = tip-apex distance.

Radiographic results

The reduction was classified as good in 53 (91.4%) cases, acceptable in three (5.2%), and regular in two (3.4%) (Figure 3).

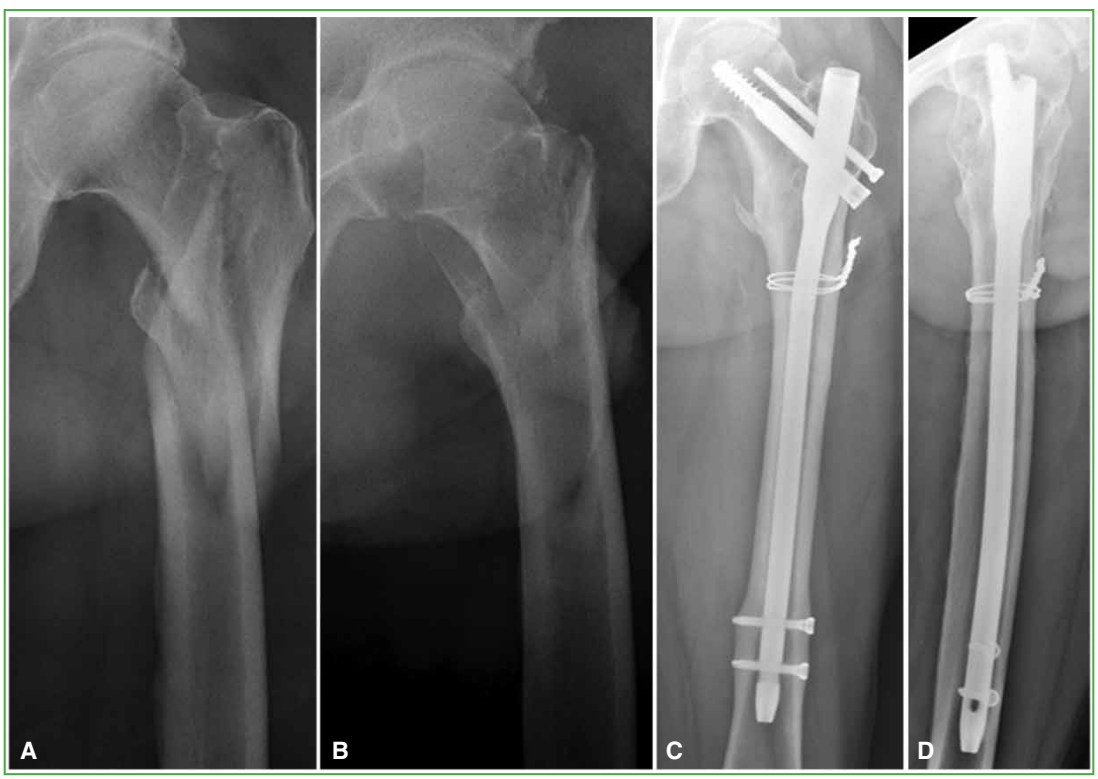

Figure 3. A and B. Preoperative anteroposterior and lateral radiographs of the left proximal femur showing a type 5 subtrochanteric fracture. **C and D.** Postoperative anteroposterior and lateral radiographs of the left proximal femur, in one of the fractures where cerclage wire was used. Good alignment and consolidation are observed in both projections.

Five (8.6%) patients, all from the group treated without wire, presented misalignment: one only in the anteroposterior view (12°); one in the anteroposterior and lateral views (12º and 10º, respectively); and two only in the lateral view (10°-15°). The remaining presented a rotational defect of 15°. The tip-apex distance of the series was 15.41 ± 3.74 mm.

The consolidation rate was 91.4% (n = 53), at an average of 15.9 weeks (range 8-32) (Table 2). The Harris hip score at the end of follow-up was 88.60 ± 3.47 (range 80-94). The median follow-up was 30 months (interquartile range 15-40).

The comparative results between the groups with and without cerclage wire are detailed in Table 2.

Complications

There were nine (15.5%) complications that required reoperations. Five patients evolved to pseudarthrosis (8.6%). Three of them were infected and were treated by prosthetic revision in two stages, with a favorable evolution. Two (3.4%) presented an aseptic pseudarthrosis, one with nail fracture, which was treated with a nail replacement, and the other with a nail replacement plus bone graft. The fracture consolidated at 22 and 26 weeks, respectively.

One patient suffered an acute infection that required surgical cleaning 20 days after the operation and subsequent antibiotic treatment. Another patient presented an internal rotation defect of 15º in the operated limb, and underwent reoperation at 48 h. Extrusion of the cephalic screw was detected in five patients, two of whom had discomfort on the lateral side of the thigh, and the screws were removed once the fractures had consolidated.

The comparative analysis of the groups showed significant differences in the presence of postoperative misalignment, while there were no significant differences regarding complications and reoperation rates (Table 3).

Table 3. Comparative detail of complications in both groups.

	Group A (with cerclage wire) (n = 20)	Group B (no cerclage wire) (n = 38)	p
Complications (n%)	3 - 15	6 – 18.4	0.99
Aseptic pseudarthrosis (n %)	1 – 5	1 – 2.6	0.99
Infected pseudarthrosis (n%)	1 - 5	2 – 5.7	0.99
Infection (n%)	1 - 5	-	0.34
Rotation defect	-	1 – 2.6	0.78
Cephalic screw removal (n %)	-	2 – 5.3	0.54
Reoperations (n %)	3 - 15	6 – 15.8	0.99

DISCUSSION

Among the main findings of this study, it is highlighted that the use of cerclage wire allowed to improve the quality of the reduction and caused a significantly lower incidence of misalignment, although it was associated with a significant increase in surgical time.

In this series, 60% of the patients who presented misalignment had to be re-operated, which highlights the importance of the reduction. We attribute this significant difference in misalignment to two points in particular. Because the loops allow a correct reduction to be achieved and maintained, they facilitate the placement of the implant at the appropriate entry point, favoring its correct positioning.[15,16]

Finsen[17] noted that, in addition to facilitating fracture reduction, cerclage wire increases the overall stability and strength of the construct, minimizing the possibility of implant fatigue. Muller et al.[18] reported similar results in their biomechanical study where they described that the use of wire loops significantly decreased the osteosynthesis failure rate.

We understand that adequate reduction is a fundamental factor for the good evolution of this type of fracture. Starr et al.[19] reported reductions with varus displacement in up to 18% of their series (2-3.4% of cases in our series). Shukla et al.[20] pointed out that this type of misalignment increases the chances of pseudarthrosis, implant fatigue, and hospitalization.

In this series, wire loops were used whenever the focus was opened. In this regard, Kennedy et al.[21] published that the opening of the fracture site without the use of wire loops causes up to 15% of reoperations due to misalignment. According to our understanding and coinciding with Afsari et al.,[4] this is generated because, by reducing the fracture with the opening of the focus on the traction table and placing the implant, on certain occasions, after releasing the traction, it is possible that the reduction is lost, at least partially.

The fracture subtype in which we used the most loops was 3A of the Seinsheimer classification. Usually, after reduction on the traction table, this fracture pattern may appear aligned when checking in the anteroposterior projection but, when evaluating the lateral projection, there may be an important misalignment (Figure 1). This displacement is not always possible to reduce with external manipulation, levers, or even with the nail itself, and requires the opening of the focus and reduction with wire loops.

In agreement with Robinet et al.,[5] and Malik et al.,[22] the use of loops in this series generated an increase in surgical time and postoperative transfusions, although the latter were not significant.

Consolidation rates were comparable to those of Trikha et al.[15] (92%) and lower than those of Kennedy et al.[21] (94.2%). Meanwhile, the need for a new procedure was higher than the 3.84% described by Robinet et al.[5] and lower than the 23% and 21% reported by Krappinger et al.,[23] and Barbosa de Toledo and Pires,[2] respectively.

Those who defend the biological fixation of the fracture and avoid the use of wire loops are based on its theoretical negative effect on the vascularization of the fracture that predisposes to consolidation problems.[24] Different histopathological studies of the femoral periosteum that describe the concept that its arteries supply nutrients longitudinally to large segments have been rejected. In this regard, Pazzaglia et al.[25] reported that, in reality, this vascularization is distributed circumferentially in the periosteum with multiple musculoperiosteal vessels that nourish it, and an average of 26 vessels per mm2 stand out, so the adverse effect of one or two loops does not significantly affect the vascularization of the fracture.

In recent years, the percutaneous placement of wire loops has gained popularity and has achieved excellent outcomes, although this requires specific instruments, which are not always available.[4,5,8] In this study, the wire loops were placed in the traditional way, with careful and meticulous handling of soft tissues, without causing a significant increase in complications, with outcomes similar to those reported with percutaneous placement.[5,8]

The limitations of this study are those of a retrospective study with a low number of patients, which limited the depth of the statistical analysis. On the other hand, the low number of reported complications may have generated a lack of statistical significance in some of the variables analyzed, causing a type 2 error. Although there was an unequal number of patients in each group, the similar distribution of their preoperative characteristics allowed for an adequate comparative analysis. The strengths are the appropriate follow-up and the fact that treatments were carried out in the same center, by the same surgical team, with identical surgical technique and pre- and postoperative evaluations.

CONCLUSIONS

The use of cerclage wire in the treatment of subtrochanteric fractures with cephalomedullary nails allowed to obtain a better quality reduction and a significantly lower incidence of displacement, with a longer surgical time. Its use was more frequent in subtype 3A fractures. Its use did not significantly affect the rates of consolidation, complications, or reoperations, at least in this series. Properly designed studies with a higher level of evidence and a higher number of patients are needed to determine the external validity of our results.

Conflict of interests: The authors declare no conflicts of interest.

A. Gessara: ORCID ID: https://orcid.org/0000-0003-2211-6162
J. Rodríguez: ORCID ID: https://orcid.org/0000-0002-1089-3071
T. Dainotto: ORCID ID: https://orcid.org/0000-0002-6645-9928
H. del Sel: ORCID ID: https://orcid.org/0000-0002-3655-1408

REFERENCES

1. Holt G, Smith R, Duncan K, Hutchinson JD, Gregori A. Gender difference in epidemiology and outcomes after hip fracture: evidence from the Scottish hip fracture adult. *J Bone Joint Surg Br* 2008;90(4):480-3. https://doi.org/10.1302/0301-620X.90B4.20264
2. Barbosa de Toledo PR, Pires RES. Subtrochanteric fractures of the femur: update. *Rev Bras Ortop* 2016;51(3):246-53. https://doi.org/10.1016/j.rboe.2016.03.001
3. Karayiannis P, James A. The impact of cerclage cabling on unstable intertrochanteric and subtrochanteric femoral fracture: a retrospective review of 465 patients. *Eur J Trauma Emerg Surg* 2020;46(5):969-75. https://doi.org/10.1007/s00068-018-01071-4
4. Afsari A, Liporace F, Lindvall E, Infante A, Sagi HC, Haidukewych GJ. Clamp-assisted reduction of high subtrochanteric fractures of the femur. *J Bone Joint Surg Am* 2009;91(8):1913-8. https://doi.org/10.2106/JBJS.H.01563
5. Robinet JM, Torres M, Moreno MB, Alonso JA, García SG. Minimally invasive clamp-assisted reduction and cephalomedullary nailing without cerclage cables for subtrochanteric femur fractures in the elderly: surgical technique and results. *Injury* 2015;46(6):1036-41. https://doi.org/10.1016/j.injury.2015.01.0119
6. Pesciallo C, Mana DP, Barrios JM, del Sel H. Fracturas subtrocantereas de fémur. Tratamiento con clavo de fémur proximal por técnica mínimamente invasiva. *Rev Asoc Argent Ortop Traumatol* 2009;74(1):13-9. Available at: https://www.aaot.org.ar/revista/2009/n1/art03.pdf
7. Rhie JT, Widmaier JC. Technique of obtaining and maintaining reduction during nailing of femur fractures. *Orthopedics* 2009;32(8):581-8. https://doi.org/10.3928/01477447-20090624-17
8. Appivatthakakul T, Phaliphot J, Leuvitoonvechkit S. Percutaneous cerclage wiring, does it disrupt femoral blood supply? A cadaveric injection study. *Injury* 2013;44(2):168-74. https://doi.org/10.1016/j.injury.2012.10.016
9. Perren SM. Evolution of internal fixation: choosing a new balance between stability and biology. *J Bone Joint Surg Br* 2002;84(8):1093-110. https://doi.org/10.1302/0301-620x.84b8.13752
10. Vaidya SV, Dholakia DB, Chatterjee A. The use of dynamic condylar screw and biological reduction techniques for subtrochanteric femur fracture. *Injury* 2003;34(2):123-8. https://doi.org/10.1016/s0020-1383(02)00319-4
11. Celebi L, Can M, Muratli HH, Yagmurlu MF, Yuksel HY, Sicimoglu AN. Indirect reduction and biological internal fixation of comminuted subtrochanteric fractures of the femur. *Injury* 2006;37(8):740-50. https://doi.org/10.1016/j.injury.2005.12.022
12. Seinsheimer F. Subtrochanteric fractures of the femur. *J Bone Joint Surg Am* 1978;60:300-6. PMID: 649632
13. Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM. The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. *J Bone Joint Surg Am* 1995;77:1058-64. https://doi.org/10.2106/00004623-199507000-00012
14. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. *J Bone Joint Surg Am* 1969;51(4):737-55. PMID: 5783851
15. Trikha V, Saudhik D, Prabhat A, Arkesh M, Sunil KD. Role of percutaneous cerclage wire in the management of subtrochanteric fractures treated with intramedullary nails. *Chin J Traumat* 2018;21(1):42-9. https://doi.org/10.1016/j.cjtee.2018.01.001
16. Tomas J, Teixidor J, Batalla L, Pacha D, Cortina J. Subtrochanteric fractures: treatment with cerclage wire and long intramedullary nail. *J Orthop Trauma* 2013;27:e157-160. https://doi.org/10.1097/BOT.0b013e31826fc03f
17. Finsen V. The effect of cerclage wires on the strength of diaphyseal bone. *Injury* 1995;26(3):159-61. https://doi.org/10.1016/0020-1383(95)93493-2
18. Muller T, Topp T, Kuhne CA, Gebhart G, Ruchholtz S, Zetti ARE. The benefit of wire cerclage stabilization of the medial hinge in intramedullary nailing for the treatment of subtrochanteric femoral fractures: a biomechanical study. *Int Orthop* 2011;35(8):1237-43. https://doi.org/10.1007/s00264-010-1204-4
19. Starr AJ, Hay MT, Reinert CM, Borer DS, Christensen KC. Cephalomedullary nails in the treatment of high-energy proximal femur fractures in young patients: a prospective, randomized comparison of trochanteric versus piriformis fossa entry portal. *J Orthop Trauma* 2006;20(4):240-6. https://doi.org/10.1097/00005131-20060400-00002
20. Shukla S, Johnston P, Ahmad MA, Wynn-Jones H, Patel AD, Walton NP. Outcome of traumatic subtrochanteric femoral fractures fixed using cephalomedullary nails. *Injury* 2007;38(11):1286-93. https://doi.org/10.1016/j.injury.2007.05.013

21. Kennedy MT, Mitra A, Hierlihy TG, Harty JA, Reidy D, Dolan M. Subtrochanteric hip fractures treated with cerclage cables and long cephalomedullary nails: a review of 17 consecutive cases over 2 years. *Injury* 2011;42(11):1317-21. https://doi.org/10.1016/j.injury.2011.03.023
22. Malik MHA, Harwood P, Diggle P, Khan SA. Factors affecting rate of infection and nonunion in intramedullary nailing. *J Bone Joint Surg Br* 2004;86(4):556-60. PMID: 15174553
23. Krappinger D, Wolf B, Dammerer D, Thaler M, Schwendinger P, Lindtner RA. Risk factors for nonunion after intramedullary nailing of subtrochanteric femoral fractures. *Arch Orthop Trauma Surg* 2019;139(6):769-77. https://doi.org/10.1007/s00402-019-03131-9
24. Edwards C, Counsell A, Boulton C, Moran CG. Early infection after hip fracture surgery: risk factors, cost and outcomes. *J Bone Joint Surg Br* 2008;90(6):770-7. https://doi.org/10.1302/0301-620X.90B6.20194
25. Pazzaglia UE, Coniu T, Raspanti M, Ranchetti F, Quacci D. Anatomy of the intracortical canal system. Scanning electron microscopy study inrabbit femur. *Clin Orthop Relat Res* 2009;467(9):2446-56. https://doi.org/10.1007/s11999-009-0806-x