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Original article

Distal femur fractures. Comparative analysis of two different surgical treatments

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ABSTRACT. ***Introduction:*** **The treatment of distal femur fractures has been a controversial topic and it has recently evolved towards indirect reduction and minimally invasive techniques.** ***Objective:*** **To compare the results of the surgical treatment of distal femur fractures with a plate with screws for condylar compression purposes with the minimally invasive stabilization system.** ***Material and methods:*** **Patients with distal femur fractures treated surgically between January 2007 and December 2009 were assessed retrospectively. The following variables were registered from each patient record: age, sex, type of fracture, mechanism of injury, type of implant used, operative time and postoperative bleeding. The Neer scale was used to compare the anatomical, radiologic and functional results of both techniques.** ***Results:*** **The total number of patients was 52; 32 males and 20 females; mean age was 58 years. A plate with screws was used in 31 patients for condylar compression purposes, and a minimally invasive stabilization system in 21. The cases managed with a minimally invasive stabilization system had a shorter operative time and less intraoperative bleeding. The results of the evaluation using the Neer scale were similar for both modalities.** ***Conclusions:*** **The patients with fracture of the distal third of the femur managed with a minimally invasive stabilization system had**

RESUMEN. ***Introducción:*** **El tratamiento de fracturas femorales distales ha sido un tema controvertido y recientemente ha evolucionado hacia técnicas de reducción indirecta y mínima invasión.** ***Objetivo:*** **Comparar los resultados del tratamiento quirúrgico de fracturas distales del fémur mediante el uso de placa con tornillos para compresión condílea y con el sistema de estabilización mínimamente invasivo.** ***Material y métodos:*** **Se evaluaron retrospectivamente pacientes con fractura del tercio distal del fémur tratados quirúrgicamente entre Enero de 2007 y Diciembre 2009. De cada expediente se registraron la edad, sexo, tipo de fractura y mecanismo de producción, implante utilizado, tiempo quirúrgico y sangrado transoperatorio. Se utilizó la escala de Neer para comparar los resultados anatómicos, radiológicos y funcionales entre ambas técnicas.** ***Resultados:*** **52 pacientes en total de los cuales treinta y dos pacientes fueron hombres y 20 mujeres; la edad promedio de los pacientes fue 58 años. En 31 pacientes se utilizó placa con tornillos para compresión condílea y en 21 un sistema de estabilización mínimamente invasivo. Se encontró menor tiempo quirúrgico y menor sangrado transoperatorio en casos manejados con sistema de estabilización mínimamente invasivo. Los resultados de la evaluación mediante la escala de Neer fueron similares entre ambas modalidades.**

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better outcomes, which were not significant in the Neer scale, mainly due to less pain intensity, early mobilization and less functional repercussions.

Key words: fracture, femur, knee, surgery, technic, comparative study.

Conclusiones: **Los pacientes con fractura del tercio distal del fémur manejados mediante sistema de estabilización mínimamente invasivo presentaron mejores resultados, aunque no significativos en la escala de Neer, principalmente debido a una menor intensidad del dolor, con una pronta movilización y menor repercusión funcional.**

Palabras clave: fractura, fémur, rodilla, cirugía, técnica, estudio comparativo.

Introduction

Throughout the historic evolution of orthopedic surgery the treatment of distal femur fractures has not achieved clinical results with a quality comparable to the rest of the femoral fractures. The presence of thin cortices, osteoporosis, wide medullary canals, and fracture comminution make it difficult to obtain and maintain a stable fixation.[1] The goal of the treatment of these fractures is the anatomic reduction of the articular surface, restoration of the limb length, alignment and rotation, as well as allowing for an early limb mobilization to avoid articular stiffness and the loss of muscle mass.[2]

Distal femur fractures represent 4-6% of all the femoral fractures and they occur within the 9 terminal centimeters, between the shaft-metaphyseal junction and the femoral condyles. They occur with a bimodal distribution within an age range of 15-50 years. They predominate in males, who are more frequently involved in high energy traumas, and the extension of the fracture to the shaft region is not infrequent. On the other hand, they are predominant in female elderly patients, in whom there is usually a low energy mechanism involved; the presence of osteopenia and gonarthrosis may complicate their management. Moreover, there is a high rate of open distal femur fractures.[3,4]

The treatment of distal femur fractures has long been a controversial topic. Towards 1950-1960 the conservative approach was predominant.[5] In 1963, AO introduced the fixed angled plate for the treatment of distal femur fractures and reported 73.5% of good or excellent results in 112 patients. These attempts were related with high complication rates. The most frequently reported problems included various types of infections, healing failure or delay, need for graft placement, and articular stiffness due to the difficulty for early patient mobilization.[6-8]

Schatzker and Lambert in 1979 reported a total of 35 distal femur fractures treated with internal fixation using a 95° angled plate and a reinforced condylar plate. Those authors had overall good or excellent results in 45% of cases.[9] However, better results were gradually obtained throughout the following 20 years due to the ongoing improvement of the implants used with the various surgical techniques. Thus, by the eighties several authors had reported the treatment of distal femur fractures with lateral fixation implants. Most of the fractures were fixed with a condylar plate or by means of a plate with condylar compression screws. With this type of implants bone healing was achieved in a period of 2.5-5 months.[10] Schatzker et al. (1989) evaluated prospectively 19 patients with distal femur fractures treated with a plate with condylar compression screws; they reported good functional results in 17 patients with clinical and radiologic evidence of healing, and two patients had delayed healing.[11] In 1988, Green introduced to orthopedic surgery the use of a new intramedullary nail placed in a retrograde fashion.[12] This author reported a total of 38 patients, 20 of whom were managed with the retrograde nail technique and 18 with various lateral fixation methods. Since the work of Moed et al. carried out in 1995-1998 evaluating the results of the retrograde centromedullary nail, this technique positioned itself as part of the resources available to the orthopedic surgeon.[13,14]

The surgical treatment of long bone fractures has evolved emphasizing the minimization of the additional biologic damage caused by the surgical trauma. Indirect reduction techniques consisting of exerting traction through the soft tissues to achieve fracture reduction have been introduced and they have gradually replaced the open reduction techniques. This indirect approach is known as internal biologic fixation.[15,16]

Together with the former, various minimally invasive techniques have been implemented recently. The implant known as less invasive stabilization system (LISS) stands out among them and consists of a pre-contoured plate that may be percutaneously inserted after the closed reduction of the fracture.[16]

The objective of this study is to present the results of the surgical treatment of supracondylar femoral fractures (types A, B, C) according to the AO/ASIF classification using two treatment modalities: a plate with condylar compression screws and the less invasive stabilization system.

Material and methods

This observational, retrospective, cross-sectional study reviewed the clinical files of all patients who underwent

surgery due to a distal femur fracture from January 2007 to December 2009. Before starting the study, the Hospital Review Board approved this retrospective study and granted a waiver of informed consent. The study was conducted observing the Health Insurance Portability and Accountability Act of the United States health insurance.[17]

The inclusion criteria were as follows: Firstly, complete clinical records; second, patients with distal femur fracture including all degrees of severity; third, the fractures must have been surgically treated either with open reduction and a plate with condylar compression screws or through indirect reduction and a less invasive stabilization system; fourth, patients followed-up as outpatients for at least six months. Patients less than 18 years of age were excluded as well as those with an interval between the fracture and the surgical treatment longer than 7 days, patients with a fracture treated initially with a different type of implant, and those with a diagnosis of periprosthetic fracture.

Applying these selection criteria, a total of 52 patients were identified and constituted the sample. The following variables of each patient record were analyzed: Age, sex, mechanism of fracture, type of fracture according to the AO/ASIF classification,[18] surgical treatment modality, operative time and volume of intraoperative bleeding. On the other hand, during the follow-up at postoperative weeks 4, 8 and 12 the following variables were recorded: Pain occurrence and severity, range of motion of the knee joint, radiologic evidence of healing, and complications. On the other hand, the results obtained at postoperative month 6 were assessed using the modified Neer scale.[19]

The statistical analysis consisted of descriptive statistics (percentage, range, mean, standard deviation), using the standard methods. The comparison of variables between both treatment modalities was done using the chi-square test for the categorical variables and the Student t test for the independent samples in the case of numerical variables. The comparison of ordinal variables of the Neer scale was performed using the Kruskal-Wallis test.

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Results

The review included a total of 52 patients, 61% of whom were males (32/52) and 39% females (20/52). Patient age ranged between 18 and 88 years, with a mean age of 58 years; the distribution in age groups is shown in *chart 1*.

A high-energy mechanism was reported as the cause of fracture in 73% of cases (38/52), and a low energy mechanism was reported in 27% (14/52). None of the patients had bilateral fracture, so according to the AO/ASIF classification, among the 52 fractures the predominant type was 33A 1.1, reported in 31% of cases (16/52), followed by types 33A 1.2, with a frequency of 15% (8/52) and 33C 1.1, also with a frequency of 15% (8/52). The distribution of fractures according to their frequency based on the types included in this classification is summarized in *table 1*.

Of the total number of fractures, 78% (41/52) were closed and 22% (11/52) were open. According to the Gustilo classification,[20] 3/11 open fractures were type I, 1/11 was type II and 7/11 were type IIIA. Fifty-five percent of the fractures (29/52) involved the right pelvic limb and 45% (23/52) the left one.

According to the surgical treatment modality for fracture fixation, in 31/52 patients (59%) an implant consisting of a plate with condylar compression screws was used (Group I), and in 21/52 patients (41%) the less invasive stabilization system was used (Group II).

When comparing the overall characteristics of the patients in each group, no significant differences were found in age and sex. However, a significant predominance was found in the proportion of fractures caused by a high energy mechanism in Group I patients *(Table 2)*.

The distribution of fractures according to the AO/ASIF classification for each treatment modality is summarized in *table 3*.

A longer duration of the surgical procedure was seen in Group I, with a mean of 135 minutes, compared with Group

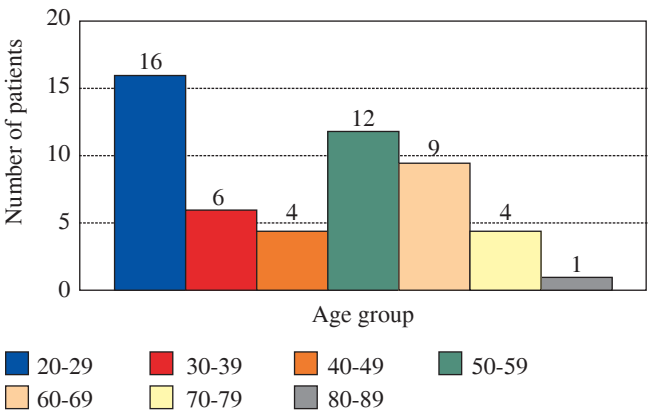


Chart 1. Distribution of patients by age group.

Table 1. Distribution of distal femur fractures according to the AO/ASIF classification.

Type	Number of fractures	Relative frequency (%)
33 A 1.1	16	31
33 A 1.2	8	15
33 C 1.1	8	15
33 A 2.1	4	8
33 A 2.2	4	8
33 A 3.3	2	4
33 A 1.3	2	4
33 B 1.2	2	4
33 C 1.3	2	4
33 A 2.3	1	2
33 A 3.1	1	2
33 B 1.1	1	2
33 C 1.2	1	2
Total	52	100

II, with a mean duration of 85 minutes, with a statistically significant difference *(Table 4)*. The intraoperative bleeding volume was greater in the cases in which the implant consisting of a plate with condylar compression screws was used (mean bleeding: 784 cc), compared with Group II, which had a mean bleeding volume of 333 cc, with a statistically significant difference between them *(see Table 4)*.

In 51% of the cases (16/31) in Group I a graft was used. No graft was used in Group II because the fracture site was intact.

During the outpatient follow-up patients in Group I reported significantly greater pain intensity at postoperative month 2, as shown in *chart 2*. Pain intensity became similar in both groups by postoperative month 6 *(Chart 3)*.

When the degrees of flexion obtained at postoperative months 1, 2 and 3 were compared, no significant differences were seen between both treatment modalities *(Table 5)*.

The degree of bone healing was assessed at postoperative months 1, 2 and 3 for each of the groups; it is summarized in *table 6*.

Patients in whom a plate with condylar compression screws was used stopped using crutches and used a cane or a walker at a mean of 20 weeks after surgery. A statistically significant difference was seen when this figure was compared with the group of patients in whom the less invasive stabilization system was used, who used a cane or a walker at a mean of 9.6 weeks (p 0 0.019).

The Neer scale showed that excellent results were obtained in 61% of patients in Group I (19/31) *(Table 7)*. The functional results in 6/31 patients were affected by the need to use a cane or a walker due to the severity of their pain. Additionally, 4/31 patients had a valgus deformity of less than 5°, and two patients had a 10° rotational deformity together with a 10° valgus deformity. The results in 71% (15/21) of the patients in Group II were excellent; 5/21 patients had functional restriction due to the severity and ongoing nature of their pain. One patient (1/21) had a valgus deformity of less than 5°.

Discussion

Fractures of the distal femur are important injuries that frequently lead to permanent disability. The magnitude of the functional loss results from the combination of injuries at the level of the distal femur, the articular cartilage and the surrounding soft tissues.[1,16]

These fractures may encompass the femur shaft with limited effects on the knee, or they may occur at the level of the supracondylar metaphysis and remain as extra-articular, although sometimes they go all the way to the attachments of the collateral ligaments (epicondyles). In other cases the fracture may compromise a single condyle (monocondylar

Table 2. Patient characteristics and mechanism of injury.

	Group I	Group II	p Value
N	31	21	
Age	50.8 ± 14.5	49.83 ± 23.6	0.67*
Gender	Males 19/31	Males 13/21	
	Females 12/31	Females 8/21	0.964†
Mechanism	High energy 26/31	High energy 12/21	
of injury	Low energy 5/31	Low energy 9/21	0.034†

* Student t test
† Chi-square

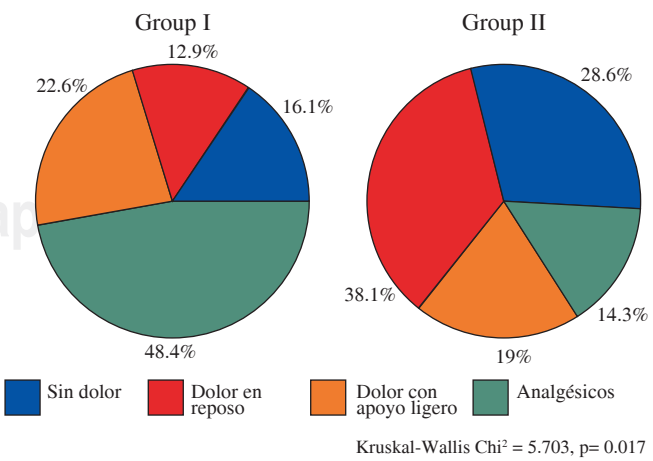
Table 3. Distribution of fractures by group according to the AO/ASIF classification.

Type	Group I	Group II
33A 1.1	9/31	7/21
33A 1.2	5/31	3/21
33C 1.1	6/31	2/21
33A 2.1	2/31	2/21
33A 2.2	3/31	1/21
33A 3.3	2/31	
33A 1.3	1/31	1/21
33B 1.2	1/31	1/21
33C 1.3	1/31	1/21
33A 2.3	1/31	
33A 3.1		1/21
33B 1.1		1/21
33C 1.2		1/21

Table 4. Comparison of the operative time and the intraoperative bleeding.

	Group I	Group II	p Value
Operative time (minutes)	135.16 ± 7.5	85 ± 7.07	0.042†
Bleeding volume (cc)	684 ± 113.88	454 ± 98.17	0.039†

† Student t test



Kruskal-Wallis Chi² = 5.703, p= 0.017

Chart 2. Distribution of patients by severity of pain at two months postoperative.

fractures) with the other condyle and the shaft remaining intact. Often times the fracture is located at the supracondylar level, but it may extend inferiorly towards the articular surface with different degrees of comminution, as in supracondylar-intercondylar fractures.[21]

Recently, the treatment of these fractures has evolved towards a balance between the mechanical stability of the fragments and the biological viability, observing the principles of the anatomic reduction of the articular surfaces and the restoration of the femur length, as well as of the articular alignment and rotation.[2,15]

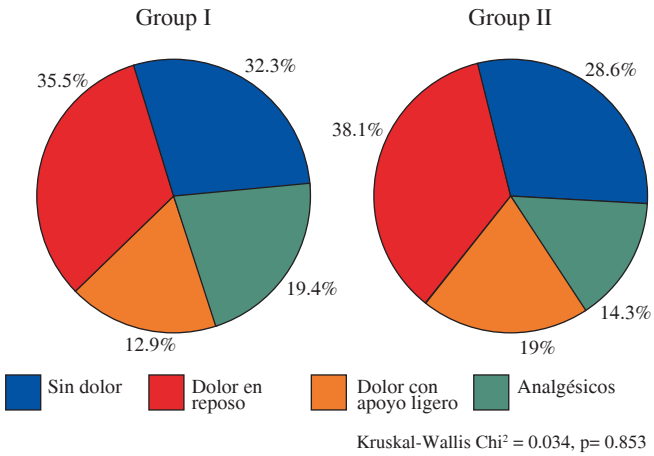


Chart 3. Distribution of patients by severity of pain at six months postoperative.

Table 5. Evaluation of postoperative flexion (Degrees).

	Group I	Group II	p Value
Flexion at one month	31.20 ± 5.40	28.66 ± 12.83	0.987†
Flexion at two months	94.2 ± 10.25	96.83 ± 38.93	0.834†
Flexion at three months	102.5 ± 5.62	112.8 ± 23	0.522†

† Student t test

There are two well recognized patterns related with the mechanism of injury: high energy injuries in young patients and low energy injuries in older patients. It is known that 45% of the distal femur fractures occur as a result of minor trauma in osteoporotic bones, often times when an elderly patient falls on a flexed knee.[1,3]

In this paper we found that in patients treated with a plate with condylar compression screws, a high energy mechanism of fracture was predominant. Even though this may reflect a difference in the severity of injuries between the groups and may be a characteristic inherent to retrospective studies, so far there are no reports distinguishing between the treatment choice according to the mechanism of fracture and the results gathered for analysis purposes.[1,22] For this reason we consider that this reflects the transition towards a predominant management of distal femur fractures with less invasive techniques in patients with osteopenia in whom a low energy mechanism of fracture is involved. This is recommended by some authors, including Wong et al., who published a series of 16 elderly patients with a mean age of 75 years, with a distal femur fracture, who were managed using a less invasive stabilization system. In their paper only two patients had loosening of the proximal fixation and in all cases healing was complete and was verified at postoperative week 30 as a mean. Therefore, these authors stated that this system was very effective for the treatment of this type of fractures in osteopenic bones.[23]

The experiences of various authors have shown a shorter operative time and less bleeding when the less invasive stabilization system was used compared to the plate with condylar compression screws. It is therefore no surprise that our study showed the same. In fact, such comparative data were obtained even with the minimally invasive placement of a plate with condylar compression screws.[24]

An important datum found in this paper was the shorter time required for the early mobilization of patients in whom the less invasive stabilization system was used, as the latter favors the early mobility of patients for walking and flexing the knee, thus avoiding the delay in recovering the ranges of motion that results from muscle weakness.

Table 6. Evaluation of bone healing in both groups.

	Group I		Group II		
	Grade	N	Grade	N	p Value
Healing at one month	Null	4/31	Null	10/21	$Chi^2 = 1.94$
	Incipient	27/31	Incipient	11/21	p = 0.1636
Healing at two months	Null	5/31	I	4/21	$Chi^2 = 1.27$
	Incipient	12/31	I-II	5/21	p = 0.5296
	Complete	14/31	II	12/21	
Healing at three months	Incipient	2/31	Incipient	2/21	$Chi^2 = 0.16$
	Complete	29/31	Complete	19/21	p = 0.6862
Healing at six months	Delayed	2/31	Delayed	1/21	$Chi^2 = 0.06$
					p = 0.0810

Table 7. Evaluation of results according to the Neer-Grantha-Shelton Scale.

	Group I	Group II
Excellent	61.30% (19/31)	71.42% (15/21)
Satisfactory	19.35% (6/31)	9.52% (2/21)
Unsatisfactory	9.67% (3/31)	14.28% (3/21)
Poor	9.67% (3/31)	4.76% 1/21)

† Kruskall-Wallis 5.9735
p = 0.99

On the other hand, 2/31 fractures with delayed healing were reported in the patients treated with a plate with condylar compression screws, and 1/21 fractures with delayed healing in the group of patients treated with the less invasive stabilization system. Concerning consolidation, Jeon et al[25] reported complete healing in 94% of patients in 16 fractures of the distal femur treated with a plate with condylar compression screws. Kregor et al reported complete healing in 93% of the distal femur fractures treated with the less invasive stabilization system.

Moreover, no differences were seen in the range of motion between both groups and the results obtained were similar to the ones reported by Kao et al. These authors found a range of motion of 111° in the knee joint at postoperative month 31 in 26 patients with distal femur fractures treated with a plate with condylar compression screws, and of 116° in 19 patients treated with the less invasive stabilization system.

When the results were compared using the Neer scale, no statistically significant difference was shown between both treatment modalities. However, it was seen that the prompt patient mobilization, the lesser soft tissue morbidity and the lower pain intensity are important factors for better patient outcomes with the less invasive stabilization system.

Conclusions

Overall, the treatment of distal femur fractures represents a special challenge for the orthopedist surgeon due to all the factors taken into account -such as the type of fracture, the bone quality, the time course and the overall status of the patient- to obtain an appropriate postoperative course.

The plate with condylar compression screws involves a greater invasion of the soft tissues, which leads to more bleeding and the need for bone deperiostization for its placement. This increases the risk of postoperative complications in the elderly patients with a thin metaphyseal cortex and osteoporotic bone. Thus the use of the less invasive stabilization system is being preferred for the distal femur fractures that are usually caused by low energy mechanisms and where one expects to find osteopenic bone.

No significant differences were found in the degree of bone healing or in the recovery of the ranges of motion between both modalities.

During the overall evaluation of the results using the Neer scale, no significant difference was found based on the implants used. However, a significantly earlier mobilization was observed in the patients treated with the less invasive stabilization system, thus avoiding the possible complications that occur in patients who remain in complete rest for long periods of time.

The major factor influencing the results was the presence and severity of pain, which had direct repercussions on the patients' rehabilitation and their resumption of their activities.

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