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Mortality of distal femur fractures in the elderly

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ABSTRACT

Introduction: the frequency of distal femur fractures in the elderly is rapidly increasing. A study of these fractures was conducted in our center in order to evaluate the comorbidities and the mortality associated with this entity.

Material and methods: all the distal femur fractures by low energy in patients over 65 years old at a tertiary center were included, between January 2010 and December 2016. Baseline characteristics, the type of fracture, comorbidities, and functional status before admission, were collected. The relationship of each of these variables to the final functional class, immediate and late complications and mortality during the follow-up. Fifty-nine patients were included, with a median age of 85.3 years (IQR 78.6–91.6). Fifty-one patients were women. In 10 patients, the fractures were atraumatic (postural change mainly in non-walking patients), and in 54 of the cases were treated surgically (6 with retrograde intramedullary nailing and 48 with lateral locking plate). The median time to surgery was 4.5 days (IQR 2–6) and 14 patients were operated within 48 hours. The median follow-up was 26.3 months.

Results: fourteen patients died during the first year of follow-up. Factors independently associated with death during the first year after the fracture were: conservative treatment, and the inability to ambulate before the episode. The absence of certain comorbidities, such as chronic heart disease, and cancer, and an age under 80 years, behaved as protective factors.

Conclusion: low-energy distal femur fractures comprise a severe injury in the elderly and are associated with high mortality. Surgical treatment showed better outcomes in terms of survival, with no significant differences depending on the type of fracture, the type of implant or the median time to surgery.

Introduction

The progressive increase in life expectancy and the subsequent population ageing are responsible of the greater impact of frailty among our patients [1–3]. The concept of frailty defines the biologic syndrome characterized by decreased functional reserve, caused by a pooled decline of multiple physiologic systems, that origins loss of homeostatic capability and higher vulnerability to adverse events such as falls, fractures, disability, institutionalization and death [4,5. Frailty prevalence in over 65 years-old people is high, between 7 and 16%.

Fractures in the elderly implies an important clinical impairment, worsening quality of life and functional status, as well as higher mortality [6]. This fact has been largely studied in hip fractures in the elderly [6–8], nonetheless, there is scarce literature about lower limb fractures in other locations in frail patients, such as distal femur, despite the potential high risk of severe complications, including death.

Low energy distal femoral fractures in the elderly, despite being less frequent than hip fractures, present a global incidence over 60 years-old of 43 and 217/100000/year in males and females, respectively, and is progressively increasing [9,10]. The aim of the herein study is to assess mortality in distal femur fractures in the elderly and to identify demographic and clinical risk factors associated, in order to improve our knowledge about this subgroup of patients in this clinical setting.

Patients and methods

This is a retrospective observational study with consecutive data collection from digital medical records, surgical protocols, and imaging studies. Our study population included all 65-year-old patients or older. A total of 59 patients diagnosed with low-energy distal third femur fractures were evaluated in the period from 1st January 2010 to 31st December 2016, in a single tertiary hospi-

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Charlson Comorbidity Index (abbreviated version)	Score
Brain vascular disease	1
Diabetes mellitus	1
Chronic Obstructive Pulmonary Disease	1
Chronic heart failure/ Ischemic heart disease	1
Dementia	1
Peripheral vascular disease	1
Chronic kidney disease (dialysis)	2
Cancer	2
Total =	

Fig. 1. Charlson Comorbidity Index (CCI) (abbreviated version) [11]

tal. The study protocol was previously approved by the local ethics committee of our center.

Demographic variables such as sex and age at diagnosis were collected and analyzed, as well as clinical and pre-fracture functional class-related variables. For the assessment of the ambulation status, the FAC (Functional Ambulation Classification) [11] score was used and patients were classified into two groups according to their mobility: independent (FAC $>$ 2) or dependent (FAC $\leq$ 2). Moreover, ASA (American Society of Anesthesiologists) scale was used to evaluate surgical risk: low risk (ASA I), moderate risk (ASA II), high risk (ASA III) and very high risk (ASA IV).

From a clinical point of view, main comorbidities were collected [stroke, diabetes mellitus, chronic obstructive pulmonary disease (COPD); heart disease (including heart failure and ischemic heart disease), dementia, peripheral artery disease, chronic kidney disease, and active cancer], as well as the most relevant medical treatments, including the use of anticoagulant therapies. Abbreviated Charlson Comorbidity Index (CCI) (Fig. 1) (was used for the clinical assessment of the patient) [12]. The median age at diagnosis was 85.3 years (IQR 78.6–91.6), 51 cases of 59 were female. During the follow-up, a progressive increase in cases per year was observed, from the initial 5 cases in 2010 to 11 in 2016. The baseline characteristics are including in Table 1.

According to the characteristics of the fracture, the injury mechanism (low-energy trauma or fractures without trauma, in particular, those related to postural changes in non-walking patients) was evaluated. The presence of joint extension, the association with a previous implant (knee prosthesis, hip prosthesis or femoral osteosynthesis), and the presence of joint stiffness in the knee and/or hip were evaluated. The injury mechanism, in 10 patients it was unknown, compared to the other 49 patients who had presented a low-energy fall from their standing height. Fifty patients had previous pathology in hips or knees with loss of mobility, and in 17 patients' fractures were adjacent to a total knee prosthesis, a femoral stem of a total hip prosthesis, or a proximal femur osteosynthesis device. According to the type of fracture, only 8 cases had joint extension, the remaining fractures were located in supracondylar region or in diaphysis of distal femoral third. Regarding the injury mechanism, in 10 patients it was unknown, compared to the other 49 patients who had presented a low-energy fall from their standing height. Fifty patients had previous pathology in hips or knees with loss of mobility, and in 17 patients' fractures were adjacent to a total knee prosthesis, a femoral stem of a total hip prosthesis, or a proximal femur osteosynthesis device. According to the type of fracture, only 8 cases had joint extension, the remaining fractures were located in supracondylar region or in diaphysis of distal femoral third.

Table 1
Baseline characteristic and comorbidities

	n (N = 59)
Sex -women	51
Age $\geq$ 80 years old	40
Dementia	29
Heart disease*	22
Diabetes mellitus	21
COPD†	10
Stroke	8
Active cancer	5
Chronic renal insufficiency	2
Anticoagulated	12
Charlson's index $\geq$ 3	14
Non-walk before injury	23
Non-traumatic fracture	10
Joint fracture	8
Peri-implant fracture	17
Knee / hip stiffness	50

* Ischaemic heart disease +/- chronic heart failure, †Chronic obstructive pulmonary disease

As regards the previous clinical status, a high percentage of comorbidities was observed. All the patients had at least one comorbidity, and in 18 cases, had three or more. According to this finding, CCI was 0–1 (null) in 34 patients, 2 (low) in 11 patients, 3 or higher (high) in 14 patients. The most prevalent chronic diseases associated with distal femur fracture was cognitive impairment, which affected 29 patients, followed by chronic heart failure and/or ischemic heart disease in 22 patients. Regarding baseline medication, oral anticoagulation was present in 12 patients. The rest of chronic diseases are shown in Table 1.

In terms of previous functional status, 23 patients were not able to walk before the fracture (FAC scale score $\leq$ 2). The rest of patients were independent to walk, with or without any kind of aid.

In terms of treatment, patients were divided into two groups: those with conservative medical management, and those who underwent surgical treatment. The final decision to perform or not a surgical procedure was made in multidisciplinary teams, considering clinical status, surgery risk and also families' wishes and opinions. In those in which surgical treatment was performed, the type of osteosynthesis (locking plate or endomedular nail), the time to surgery, as well as intraoperative complications, were evaluated.

Regarding the hospital stay, the length of admission and the presence of complications (need of blood transfusion, readmission in the first month, and/or death in the first month) were collected. During the follow-up, the overall survival time after the fracture was assessed.

For the statistical analysis, categorical variables were represented as frequency and percentage, and continuous variables, including follow-up, as median and interquartile range (IQR). Categorical variables were compared by χ^2 test or Fisher's exact test. When comparing quantitative and qualitative variables, nonparametric tests were applied, such as a Mann-Whitney U test in case of qualitative variables with two categories and a Kruskal-Wallis rank test in case of more than two categories. Finally, the survival analyses were carried out based on Kaplan-Meier analyses by log-rank^2 nonparametric test, assessing mortality during the follow-up, and Cox regression were performed to evaluate the influence of independent variables in survival. All tests were two-sided and differences were considered statistically significant at P-values.

Results

Treatment, hospital admission and readmission

Surgery was performed in 54 patients. Six out of these 54 cases were treated by closed reduction and retrograde intramedullary nailing, while the other 48 cases were treated by open reduction and internal fixation with lateral locking plate. The median time to surgery was 4.5 days (IQR 2-6). It was performed within the first 48 h in 14 patients.

In terms of surgical risk according to the *ASA Scale,* it was high (ASA III) in 32 cases followed by moderate (ASA II) in 20 patients, low (ASA I) in 4 patients, and very high (ASA IV) in 3 patients. Perioperative anemia was the most frequent complication with 42 patients requiring red blood cells transfusion, followed by acute surgical wound infection in 4 patients. One out of this four cases required total knee replacement, and other one, amputation at the middle femoral third. Other complications recorded during the hospital stay were: urinary tract and respiratory infection (3 and 4 patients, respectively), bronchoaspiration (2 patients) and 4 in-hospital deaths. Seven patients required surgical re-intervention: four cases because of infection or dehiscence of the surgical wound, two cases with aseptic pseudoarthrosis, and one case because of intolerance to locking plate.

The median hospital stay was 11 days (IQR 7–18.8), and the median of days from admission to surgery was 4.5 days (IQR 2–6). During the first post-operative month, 7 patients were readmitted to hospital due to local complications of the surgical wound in 4 cases, or other non-surgical complications (3 cases).

Follow-up and mortality

The median follow-up was 26.3 months (IQR 5.6–4.8). At the end of follow-up, 31 patients had died. Regarding the cumulative mortality rate, 5 patients had died after the first month, 7 patients after the third month, 12 patients at 6 months, and 14 patients at the end of the first year. Thirty-one had died at the end of follow-up. The estimated median survival time was 48.8 months (95% CI 37–60).

Table 2
Mortality risk factors

	Survivor (n)	Deceased (n)	P value
Age > 80 years	14	26	0.006
Stroke	2	6	
Diabetes mellitus	9	12	
Heart disease*	6	16	0.016
COPD†	3	7	
Dementia	10	19	0.044
Chronic renal insufficiency	0	2	
Active cancer	0	5	
Anticoagulated	5	7	
Charlson's index ≥ 3	3	11	0.025
Surgical treatment	28	26	0.034
Non-surgical treatment	0	5	0.034
Surgery < 48 h	9	5	
Non-traumatic injury	26	23	
FAC ≤ 2	5	18	0.002
Joint fracture	4	4	
Peri- implant fracture	11	6	

* Ischaemic heart disease +/- chronic heart failure, †Chronic obstructive pulmonary disease

The differences between groups (survivors and non-survivors) in terms of demographic and clinical variables are summarized in Table 2. As shown in this table, some comorbidities such as the presence of chronic heart failure and/or ischemic heart disease, active cancer, cognitive impairment, and subsequently, a CCI ≥ 3, were more frequent among those patients who died.

Regarding functional status, there were significantly more patients unable to walk who died than those who were independent (78.3 versus 36.1%, p 0.002).

The proportion of patients who died was higher among those who received conservative medical management, in contrast to those with surgery [(100%) versus (48.1%); p 0.034]. There were no significant differences according to the injury mechanism, the type of fracture, the type of osteosynthesis, or the time to surgery.

To assess the prognostic differences in terms of mortality according to the treatment received (surgical or non-surgical), survival analyzes were performed. Significant differences were found depending on the type of treatment, with higher mortality for those patients with a conservative management [100% vs. 48.1%; $p < 0.001$]. The Kaplan-Meier analysis is represented in Fig. 2.

However, in order to evaluate the association to other risk factors for mortality in patients with supracondylar femoral fractures, a multivariate analysis was performed according to a Cox regression model.

In this model, patients with non-surgical management had an increased risk of mortality [HR 3.2 (CI 1.0–9.9); p 0.043). as well as those who were not able to walk independently before the fracture (FAC ≤ 2) [HR 4.1 (CI 1.7 -9.9); p 0.002]. The absence of ischemic heart disease and/or chronic heart failure [HR 0.4 (CI 0.2–0.9; p 0.025)], active cancer [HR 0.3 (CI 0.09–0.8; p 0.024)], and ages under 80 years [HR 0.3 (HR 0.1–0.9; p 0.032)] behaved as protective factors in terms of mortality.

Discussion

Distal third femur fractures comprise between 3.0 and 6.0 % of all femur fractures [9,12], most of which are due to low-energy trauma in elderly patients. High mortality rates have been reported in the first month, sixth month, and after the first year (6.0%, 18% and 38.0%, respectively) [12,13], figures that are similar or even higher than hip fractures [6,8,14].

Currently, the incidence of this kind of fracture has increased [10], due to its adjacent location to knee prostheses and the femoral stem of hip prostheses, as well as the progressive increase in life expectancy and a greater impact of frailty. Subsequently,

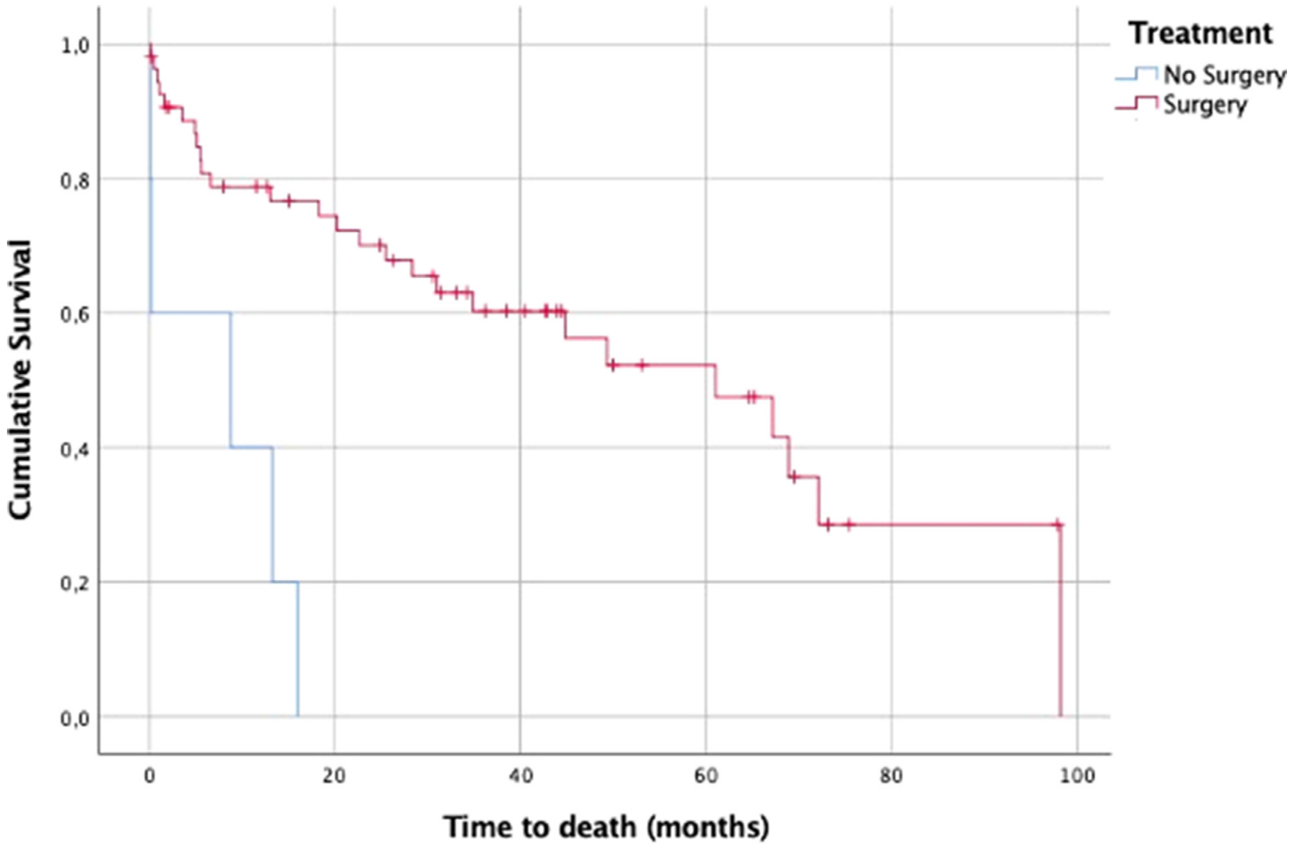

Fig. 2. Cumulative survival depending on the type of treatment (surgery in red versus conservative management in blue).

there is a new profile of patients, who are characterized by a remarkable hip and knee stiffness [15]. These fractures are the most common spontaneous fractures in institutionalized patients [16], especially in those unable to walk [15].

When comparing our results in terms of mortality at one year (23.7%), it is lower than in the majority of previous studies [14,17,18], except in the case of Myers et al, who described a mortality of 13.4% in the first year [19].

The good results in terms of survival of our study are related to the high proportion of surgically-managed patients [54 out of 59 patients (91.5%)], with a median time to surgery of 4.5 days. These results are improved by Myers et al, who have only included patients treated surgically, in which surgery was performed within the first 24 hours in 83% of cases. In those series with a higher proportion of conservatively-managed patients, 12-month mortality rises significantly (34.1% and 38.0% in the series of Jennison et al, and Jordan et al, respectively) [14,18].

In our series, those patients who did not received a surgical treatment had poor outcomes in terms of survival, having died all of them before the sixteenth month of follow-up. These results do not differ significantly from those of Larsen et al, where the risk of mortality in conservative management compared to surgical, increased 2.8 times (CI 1.41–5.54; p 0.03) [17]. Considering these results, surgical treatment seems to be the preferred option for the treatment of low-energy distal femur fractures in elderly patients; nevertheless, a previous individualized assessment is required.

According to our results, a better prognosis in terms of survival is seen in those patients without chronic heart disease, active cancer, and in patients under 80 years. Different authors have determined several variables as possible predictors of mortality in this subgroup of patients, such as heart failure, dementia and chronic kidney disease [14,19,20], including both the ASA scale and the CCI, as useful tools in the assessment of patient's frailty [18,20]. Similarly, to other studies [15,20], we have found significant differences between the presence of a CCI ≥ 3 and mortality, compared to having a CCI < 3 (11 out of 14 patients died, compared to 20 out of 45, respectively, $p = 0.025$).

According to prior functional status, patients with a FAC ≤ 2 showed a higher risk of mortality [HR 4.1 (1.7–9.9); p 0.002)]. It is particularly important to assess the risk and benefit of any kind of intervention in this subgroup of frail patients.

Regarding the type of fracture or the time to surgery, we have not found significant differences. Streubel et al, described a higher mortality in patients with periprosthetic knee fractures compared to those of the native femur (46.0 % vs 30.0 %, (HR 3.21, p 0.005) [20]. However, Kammerlander et al or Myers et al, did not find significant differences either [13,19].

In terms of time to surgery, early surgery could be theoretically beneficial to avoid complications, to improve functional recovery and to decrease mortality, nonetheless, results in literature are controversial. Myers et al [19] described a reduction in mortality at 30 days, 6 months and one year depending on the surgery timing [11.0% of mortality in early surgery ($<$ 48 h) versus 25.0% in late surgery ($>$ 48 h) [19]. On the contrary, as in our study, other authors did not find significant association between mortality and time to surgery [13,17,21,22].

Depending on the type of implant used in surgery, similarly to our study, most studies have not shown significant differences in terms of survival or biomechanical superiority with the use of nailing versus open reduction and internal fixation with lateral plate [13,17,23,24].

The main limitations of our study are based on the low sample size, which the consequent lower statistical power, as well as those intrinsic to its retrospective design.

Conclusions

Low-energy distal fractures of the femur comprise a severe kind of injury in the elderly associated with a high associated mortality. A series of indicators of poor prognosis for survival have been observed, especially those related to frailty such as the FAC score, the CCI, the ASA scale, and the presence of other comorbidities.

As regards the therapeutical management, those patients in which surgery was performed, showed better outcomes in terms of survival, with no significant differences depending on the type of fracture, the type of implant or the median time to surgery.

Declaration of Competing Interest

Nothing to declare

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2021.03.066.

References

[1] Christensen K, Doblhammer G, Rau R, Vaupel JW. Ageing populations: the challenges ahead. Lancet 2009;3:1196–208.
[2] Manton KG, Gu X, Lamb VL. Change in chronic disability from 1982 to 2004/2005 as measured by long-term changes in function and health in the U.S. elderly population. Proc Natl Acad Sci U S A. 2006;28:18374–9.
[3] Beard JR, Biggs S, Bloom DE, Fried LP, Hogan PR, Kalache A, et al. "Global Population Ageing: Peril or Promise?" PGDA Working Papers 8912, *Program on the Global Demography of Aging*, 2012. https://ideas.repec.org/p/gdm/wpaper/8912.html.
[4] Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013;2:752–62.
[5] Rodríguez-Mañas L, Féart C, Mann G, Viña J, Chatterji S, Chodzko-Zajko W, et al. Buscando una definición operativa de fragilidad: una declaración de consenso basada en el método Delphi: el proyecto de conferencia de consenso de definición operativa de fragilidad. J Gerontol A Biol Sci Med Sci 2013;68:62–7.
[6] Menéndez-Colino R, Alarcon T, Gotor P, Queipo R, Ramírez-Martín R, Otero A, et al. Baseline and pre-operative 1-year mortality risk factors in a cohort of 509 hip fracture patients consecutively admitted to a co-managed orthogeriatric unit (FONDA Cohort). Injury 2018;49:656–61.
[7] Lefaivre KA, Macadam SA, Davidson DJ, Gandhi R, Chan H, Broekhuyse HM. Length of stay, mortality, morbidity and delay to surgery in hip fractures. J Bone Joint Surg Br 2009;9:922–7.
[8] Katsoulis M, Benetou V, Karapetyan T, Feskanich D, Grodstein F, Pettersson-Kymmer U, et al. Excess mortality after hip fracture in elderly persons from Europe and the USA: the CHANCES project. J Intern Med 2017;28:300–10.
[9] Elsoe R, Ceccotti AA, Larsen P. Population-based epidemiology and incidence of distal femur fractures. Int Orthop 2018;42:191–6.
[10] Court-Brown CM, Duckworth AD, Clement ND, McQueen MM. Fractures in older adults. A view of the future? Injury 2018;49:2161–6.
[11] Viosca E, Martínez JL, Almagro PL, Gracia A, González C. Proposal and validation of a new functional ambulation classification scale for clinical use. Arch Phys Med Rehabil 2005;86:1234–8.
[12] Book: Miralles-Baseda R, Esperanza-San Juna A. *Tratado de Geriatría para residentes*. Anexo 1. Instrumentos de valoración. Edited by Sociedad española de Geriatría y Gerontología; Madrid 2019: p. 783. https://www.segg.es/tratadogeriatria/main.html.
[13] Kammerlander C, Riedmüller P, Gosch M, Zegg M, Kammerlander-Knauer U, Schmid R, et al. Functional outcome and mortality in geriatric distal femoral fractures. Injury 2012;43:1096–101.
[14] Jennison T, Divekar M. Geriatric distal femoral fractures: a retrospective study of 30-day mortality. Injury 2019;50:444–7.
[15] Martínez A, Cuenca J, Herrera A, Domingo J. Late lower extremity fractures in patients with paraplegia. Injury 2002;33:583–6.
[16] Wong TC, Wu WC, Cheng HS, Cheng YC, Yam SK. Spontaneous fractures in nursing home residents. Hong Kong Med J 2007;13:427–9.
[17] Larsen P, Ceccotti AA, Elsoe R. High mortality following distal femur fractures: a cohort study including three hundred and two distal femur fractures. Int Orthop 2020;44:173–7.
[18] Jordan R, Chahal G, Davies M, Srinivas K. A comparison of mortality following distal femoral fractures and hip fractures in an elderly population. Adv Orthop Surg 2014:1–4.
[19] Myers P, Laboe P, Johnson KJ, Fredericks PD, Crichlow RJ, Maar DC, et al. Patient mortality in geriatric distal femur fractures. J Orthop Trauma 2018;32:111–15.
[20] Streubel PN, Ricci WM, Wong A, Gardner MJ. Mortality after distal femur fractures in elderly patients. Clin Orthop Relat Res 2011;469:1188–96.
[21] Smith JR, Halliday R, Aquilina AL, Morrison RJ, Yip GC, McArthur J, et al. Collaborative - Orthopaedic Trauma Society (OTS). Distal femoral fractures: The need to review the standard of care. Injury 2015;46:1084–8.
[22] Butt MS, Krikler SJ, Ali MS. Displaced fractures of the distal femur in elderly patients. operative versus non-operative treatment. J Bone Joint Surg Br 1996;78:110–14.
[23] Bliemel C, Buecking B, Mueller T, Wack C, Koutras C, Beck T, et al. Distal femoral fractures in the elderly: biomechanical analysis of a polyaxial angle-stable locking plate versus a retrograde intramedullary nail in a human cadaveric bone model. Arch Orthop Trauma Surg 2015;135:49–58.
[24] Wähnert D, Hoffmeier K, Fröber R, Hofmann GO, Mückley T. Distal femur fractures of the elderly–different treatment options in a biomechanical comparison. Injury 2011;42:655–9.