Injury 52 (2021) 2459–2462

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Treatment of Vancouver B1 periprosthetic femoral fractures using Intrauma Iron Lady® locking plate: A retrospective study on 32 patients

A Del Chiaro*, N Piolanti, E Bonicoli, Parchi PD, S Marchetti, M Scaglione

University of Pisa, Via Paradisa 2, Pisa, IT

ARTICLE INFO

Article history:
Accepted 27 February 2021

Keywords:
Periprosthetic Femoral Fracture
PFF
Vancouver B1
Locking plate
Internal Fixation

ABSTRACT

Introduction: Periprosthetic femoral fractures (PFF) actually represent a serious public health problem. They are reported to occur in 0,1-4.5% of all patients undergoing total hip replacement (THR). PFF are commonly distinguished using the Vancouver classification. This study principal aim is to evaluate results obtained using the Intrauma Iron Lady® Conical Coupling locking plate for the treatment of Vancouver type B1 periprosthetic femoral fractures.

Materials and Methods: We enrolled 32 patients affected by Vancouver B1 PFF and treated with the same device. Metal cerclages were additionally used in 12 (38%) patients. A clinical and radiographical post-operative follow-up was then planned at 1, 3 and 6 months after surgery; than the follow-up was annually fixed.

Results: Mean age at the moment of trauma was 76,7 years. All involved femoral stem were uncemented and the they were all radiographically and intraoperativelly judged to be stable. Mean post-operative follow-up period was 5,8 years. 29 patients (91%) presented healed fracture at 6 months follow-up. 9% patients developed a superficial surgical site infection.

Discussion and Conclusions: Literature highlights that Vancouver B1 PFF should be treated with open reduction and internal fixation (ORIF) using polyaxial locking plates. However, no single technique has gained universal acceptance to be superior that the other. The current reported healing rate ranges from 40 to 100%. Using the Intrauma Iron Lady® Conical Coupling locking plate, we obtained a healing rate of 91%; this data is consistent with recent literature. Moreover, the role of cerclages in addition to femoral plating is actually controversial because they potentially damage the soft callus vascularization. Our results showed no difference in term of healing rate between patients with and without cerclages, according with some of most recent articles. A prospective study with a higher number of patients should be carried out in order to better evaluate the role of cerclages on healing rate but also the complications frequency after PFF surgical treatment.

Introduction

Periprosthetic femoral fractures (PFF) represent a serious public health problem, since the number of total hip replacement procedures performed worldwide (currently 230,000 in the USA) is expected to increase due to life expectancy changes. PFF are reported to occur in 0,1-4.5% of all patients undergoing total hip replacement (THR) [1–7]. Some conditions are actually linked with an increased risk of PFF such as: long term steroid therapy, rheumatoid arthritis and a particularly active lifestyle following the THR [8,9]. This fractures are commonly distinguished using the Vancouver Classification [10,11] (Table 1). Originally, they were been managed by nonsurgical treatment but this approach was subsequently abandoned due to augmented risk of malunion and non-union but also risks linked with a prolonged immobilisation [12,13]. Surgical treatment depends on the preoperative and intraoperative fracture classification. If the femoral stem is well fixed, an open reduction and lateral plating with or without additional cerclages

* Corresponding author at: Orthopaedic and Traumatlogy Department, University of Pisa, Via Paradisa 2, Pisa, Italy.
E-mail address: a.delchiaromd@gmail.com (A. Del Chiaro).

https://doi.org/10.1016/j.injury.2021.02.089

Table 1
Vancouver Classification of periprosthetic femoral fractures (PFF).

Type and Subtype	Characteristics
A-Type Fracture	Trochanteric region
AG	Greater Trocanther
AL	Lesser Trocanther
B-Type Fracture	Around or just distal to the stem
B1	Stem well fixed
B2	Stem lose, good bone stock
B3	Stem lose, poor bone stock
C-Type Fracture	Well below the stem

represents the actual standard of care, also in case of osteoporotic bone [14–17]. In this scenario, locking plates with a multiplanar disposition of the screws represent a possible and valuable solution, since this plate allows to fix the screws around the implant stem - also as mono cortical – in order to reach a good primary stability and then rapidly allow the patient's weight bearing. At our knowledge, only few studies with small sample size have been carried on concerning the use of lateral locking plate in proximal femoral fractures around or just distal to the stem that however remains well-fixed (Vancouver B1 fractures) [18].

The purpose of our retrospective study is to evaluate results we obtained using the Intrauma Iron Lady® Conical Coupling locking plate for the treatment of Vancouver type B1 periprosthetic femoral fractures at a mean 5,8 years follow-up.

Materials and methods

We enrolled for our study 32 patients affected by periprosthetic femur fractures and treated with the same device (Intrauma Iron Lady® Conical Coupling Locking Plate) between May 2010 and August 2016 at our Operative Unit. Inclusion criteria were: Vancouver B1 femoral fractures treated with Intrauma Iron Lady Conical Coupling Locking Plate with or without cerclages, clinical and radiographic follow-up greater than 6 months or until healed. Exclusion criteria were: Vancouver A periprosthetic femoral fractures (that are often treated nonoperatively or using plates with a trochanteric grip) [11], Vancouver B2 and B3 femoral fractures (that often require also the femoral stem replacement, even if this statement is still debated) [19–22], trasverse or short oblique fractures occurring at the tip of femoral stem (that often require femoral stem replacement, even if Vancouver B1 fractures) [23], any other reason for femoral stem replacement in addition to the locking plate for the PFF treatment, pathologic fractures (malignancy or infection), non-surgical fractures, additional bone grafting, insufficient follow-up data, intraoperative femoral fractures during THA total hip arthroplasty [24].

At the moment of trauma, each patient had two radiographic views of the fracture: an anteroposterior (AP) and a lateral (LL) view. Computed tomography scans (CT) were carried out at the moment of the fracture for all cases to better evaluate the fracture before surgery.

For each patient we recorded anagraphic data, fracture's mechanism, fracture's classification (according to Vancouver Classification) and we carried out clinical and radiological evaluation at 1, 3 and 6 months after surgery; than the follow-up was annually fixed. At every follow-up control, we performed a lateral view and an anteroposterior view, performed with the patient supine.

We performed open reduction and internal fixation of the femur fracture with the patient in lateral position on a radiolucent table. Plates were always placed on the lateral femoral wall. We also utilized cerclages, in order to stabilize the plate where the screw insertion was difficult or even impossible due to the presence of prosthetic stem. The cerclages number was chosen based on the specific fracture pattern. We always performed an initial post-operative radiographs (AP and LL) to confirm reduction quality and implant position. We used the same deep vein thrombosis and antibiotic prophylaxis for all patients. Post-operative protocol was 4 weeks of toe touch weight bearing and then a partial and progressive weight bearing to reach full weight bearing until 6-8 weeks after surgery (if there was no displacement at 4 weeks radiographical follow-up). Passive mobilization started the day after surgery. We evaluated patients performing clinical and X-ray examination with antero-posterior and lateral view of the whole femur at 1, 3 and 6 months and then yearly (Fig. 1, Fig. 2). We collected data about complications such as: infection, non-union, malunion, hardware loosening, hardware failure, and revision surgery. We considered as a "non-union" a non-healed fracture at the 6 months follow-up and as a "malunion" a fracture healed with a greater than 5° of malalignment. Infection was distinguished in deep and superficial. Deep infections were defined as those required operative treatment. Superficial infections were defined as those that were treated only with local antibiotics and wound care

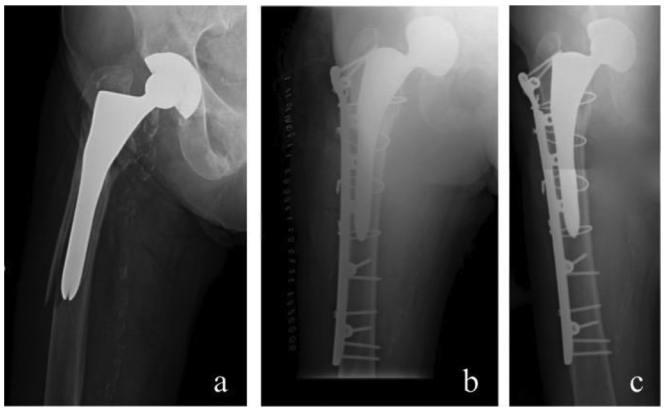

Fig. 1. A case of a 79 years old female. Radiographic examination at the moment of trauma (a), post-operative control (b) and after 12 months follow-up (c).

Statistical analysis was performed using the Statistical Package for Social Sciences, Version 13 (SPSS Inc., Chicago, Illinois). Continuous variables were showed as mean±standard deviation and discrete variables were expressed as frequency percentages. The Mann-Whitney test was used to analyze differences between non-parametric variables. For all the tests, we used a 5% level of confidence.

Results

From May 2010 to August 2016 we treated 34 cases of Vancouver B1 periprosthetic femur fracture with open reduction and internal fixation using the same device (Intrauma Iron Lady® Conical Coupling Locking Plate). Two patients were excluded from the present study because they died before the sixth month after surgical treatment. Mean age at the moment of trauma was 76,7 ± 7,8 years. Patients were 21 (66%) females and 11 (34%) males. Medium BMI was 27,3 ± 5,1. Right femur was involved in 14 cases instead left femur was involved in 18 cases. Three cases of PFF (9%) was related to high-energy trauma (HET); 29 cases (91%) of PFF was led to low-energy trauma (LET). All patients reported a Vancouver B1 periprosthetic fracture (classification confirmed by intraoperative evaluation of stem integration). All femoral stem involved in fracture were uncemented. They were all radiographically and intraoperatively judged to be stable. All surgical procedures were performed with patient lying in lateral decubitus. Implant materials was AISI 316 iron for the plates and titanium for the screws and the sockets. In six cases (19%), lateral plating was

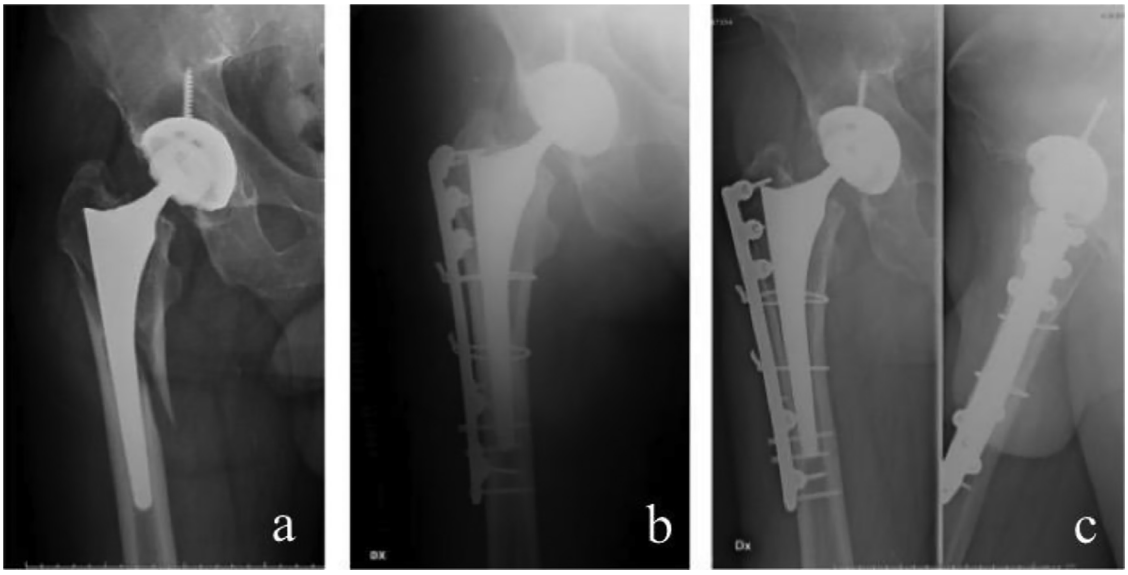

Fig. 2. A case of a 71 years old male. Radiographic examination at the moment of trauma (a), post-operative control (b) and after 12 months follow-up (c).

performed submuscolarly with a minimal invasive technique. The most used plate (18 cases) was 249 mm length (16 holes). We used a plate of 200 mm length (14 holes) in 11 cases and a plates of 300 mm (18 holes) in 7 cases. Metal cerclages were used in 12 (38%) patients to better stabilize the fracture. Mean hospital stay was 7,85±2,4 days. Mean follow-up period was 5,8 ± 2,7 years. 29 patients (91%) presented healed fracture at 6 months follow-up. 5 (16%) fractures healed in varus malalignment (6,2° mean angle). All the 3 (9%) non-unions were classified as atrophic. 2 non-unions occurred in the group of patient treated with plate and additional metal cerclages, 1 non-union instead occurred in the group treated without cerclages. No significant differences in term of non-union were found between the cerclages and no-cerclages group. All non-unions have undergone surgical treatment, except one patient (aged 93) who preferred a non-surgical management because of its age. At the last follow-up, the two re-operated non-union were healed. Using the Mann-Whitney test, we found no significant difference between patients with and without cerclages in term of healing rate. Three (9%) patients developed a superficial infection that required multiple operative debridements and IV-antibiotics. No deep infection occurred in our retrospective analysis. No patients developed a re-fracture due to the hardware failure. No hardware removal, due to the mean age of patients, was performed. We summarized our study results in Table 2.

Table 2
Brief summary of study results.

Description	Results
Enrolled Patients	32
Mean Age at Trauma	76,7 ± 7,8 years
Gender Ratio	21 F: 11 M
Medium BMI	27,3 ± 5,1
Femoral Side Ratio	14 R: 18 L
Fracture Mechanism	29 LET: 3 HET
Stem Fixation	32 Uncemented: 0 Cemented
Healing Rate	29 (91%)
Metal Cerclages Usage	12 (38%)
Mean Hospital Stay	7,85 ± 2,4 days
Mean Follow-Up Period	5,8 ± 2,7 years
Varus Malunion	5 (16%)
Superficial Surgical Site Infections	3 (9%)
Deep Surgical Sute Infections	0 (0%)
Hardware Failure	0 (0%)
Hardware Removal	0 (0%)

Discussion

Periprosthetic femoral fractures (PFF) represent a serious public health problem because of the increasing number of total hip arthroplasties (THA) combined with an aging population. Currently, periprosthetic femoral fractures are reported to occur in 0,1-4.5% of all patients undergoing total hip replacement (THR) [1–7]. Many PFF derived from low-energy traumas in elderly patients with lot of comorbidities including osteoporosis. The Vancouver classification is a world-around accepted classification scheme for PFF because of it is reliable and useful as a guide for treatment [13,25–27]. PFF treatment is actually challenging and requires expertise both in arthroplasty and fracture repair [12,28,29]. 1 year mortality after periprosthetic femoral fractures appears to be 7-18%, despite new surgical treatment techniques developed to obtain early mobilization [14,28,30,31]. It is generally accepted that Vancouver B1 fractures should be treated with open reduction and internal fixation (ORIF) but no single technique has gained universal acceptance [11,19–24]. A review from Moore [18] showed that the majority of the publications describing results of ORIF of B1 type fractures are small, retrospective case series in which the authors reported their experience with a given technique. Results of these small series have been variable with rates of union ranging from 40 to 100%. The most recent fixation techniques provide for the use of polyaxial locking plates which allow screw angling around prosthetic components and, at the same time, load distributing amongst the screw trough their angular stability [14,15,17,32,33]. Furthermore, locked plates provide for an adequate stability also when applied on an osteoporotic bone. From May 2010 and August 2016, we surgically treated 32 patients affected by Vancouver B1 PFF using the same fixation device – the Intrauma Iron Lady® Conical Coupling Locking Plate - with or without additional metal cerclages. This plate is made of iron and it has a semi-tubular shape. It acts as an internal fixator and allows a triplanar screw placement in order to surround the femoral stem. Screws are titanium made and they are locked into the plate trough a conical coupling system based on titanium sockets. Moreover, metallic cerclages can be fixed to the plates using conical coupling slotted pin. No femoral stem replacement was performed in our series. After a mean follow-up period of 5,8 years, we reported a healing rate of 91% cases. This data is consistent with recent literature [18,34]. Internal fixation may certainly damage soft tissues and periosteal

blood supply, and also cause biomechanical stress on the bone-prosthesis interface. The importance of blood supply may be supported by the finding that all the non-unions were classified as atrophic [35]. The use of cerclages in addition to lateral plating is controversial because they could negatively influence the soft callus formation. However, previous studies did not find any negative effect of cerclages on bone healing [16,34,36–39]. Our data, despite the small sample size, seemed to confirm this statement. We found a delayed wound-healing rate of 6%, which is consistent with data reported in literature [37,40].

Conclusions

Iron Lady Conical Coupling locking plates offer good results in treatment of Vancouver B1 periprosthetic femoral fracture; these results are consistent with previous literature with the use of other device [32-34]. The main strength of this study is the high homogeneity of our sample that included patients with the same fracture type and subtype and the same treatment with a single fixation device. Moreover, despite these strict criteria, our sample size resulted comparable with other studies reported in literature on this topic [18]. Instead, the major limitations of this study are: a) the small samples size (however is almost the same of other previous studies on this subject); b) the retrospective design of the study; c) the lack of a control group treated with another surgical technique. A prospective study with a higher number of enrolled patients should be carried out in order to better evaluate complications rate and the controversial role of cerclages on fracture healing.

Acknowledgments

The authors of this manuscript express their thanks to the *Intrauma SPA* that provide for gold open access publication fee for this article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2021.02.089.

References

[1] Hall MJ, DeFrances CJ, Williams SN, Golosinskiy A, Schwartzman A. National Hospital Discharge Survey: 2007 summary. Natl Health Stat Report 2010;4(29):1–20.
[2] SM R, M C, C M, AP R. Late peri-prosthetic femoral fracture as a major mode of failure in uncemented primary hip replacement. The Journal of Bone and Joint Surgery British volume 2011;93-B(2):178–83.
[3] Scott RD, Turner R, Leitzes S, Aufranc O. Femoral fractures in conjunction with total hip replacement. The Journal of bone and joint surgery American 1975;57(4):494–501 *volume*.
[4] Adolphson P, Jonsson U, Kalen R. Fractures of the ipsilateral femur after total hip arthroplasty. Archives of orthopaedic and traumatic surgery 1987;106(6):353–7.
[5] Cool P, Weidema W. Proximal femoral fractures in conjunction with hemiarthroplasty according to Moore. The Netherlands journal of surgery 1988;40(5):139–41.
[6] Fitzgerald JR, Brindley G, Kavanagh B. The uncemented total hip arthroplasty. Intraoperative femoral fractures. Clinical orthopaedics and related research 1988(235):61–6.
[7] Fredin HO, Lindberg H, Carlsson AS. Femoral fracture following hip arthroplasty. Acta orthopaedica Scandinavica 1987;58(1):20–2.
[8] Parvizi J, Jain N, Schmidt AH. Periprosthetic knee fractures. Journal of orthopaedic trauma 2008;22(9):663–71.
[9] Moazen M, Jones AC, Jin Z, Wilcox RK, Tsiridis E. Periprosthetic fracture fixation of the femur following total hip arthroplasty: a review of biomechanical testing. Clinical Biomechanics 2011;26(1):13–22.
[10] Lee S, Kagan R, Wang L, Doung YC. Reliability and Validity of the Vancouver Classification in Periprosthetic Fractures Around Cementless Femoral Stems. J Arthroplasty 2019;34(7S):S277–SS81.
[11] Gaski GE, Scully SP. In brief: classifications in brief: Vancouver classification of postoperative periprosthetic femur fractures. Clin Orthop Relat Res 2011;469(5):1507–10.
[12] McELFRESH EC, MB COVENTRY. Femoral and pelvic fractures after total hip arthroplasty. JBJS 1974;56(3):483–92.
[13] Duncan CP, Masri BA. Fractures of the femur after hip replacement. Instr Course Lect 1995;44:293–304.
[14] Ricci WM. Periprosthetic femur fractures. Journal of orthopaedic trauma 2015;29(3):130–7.
[15] Moloney GB, Westrick ER, Siska PA, Tarkin IS. Treatment of periprosthetic femur fractures around a well-fixed hip arthroplasty implant: span the whole bone. Arch Orthop Trauma Surg 2014;134(1):9–14.
[16] Hoffmann MF, Burgers TA, Mason JJ, Williams BO, Sietsema DL, Jones CB. Biomechanical evaluation of fracture fixation constructs using a variable-angle locked periprosthetic femur plate system. Injury 2014;45(7):1035–41.
[17] Strauss EJ, Schwarzkopf R, Kummer F, Egol KA. The current status of locked plating: the good, the bad, and the ugly. J Orthop Trauma 2008;22(7):479–86.
[18] Moore RE, Baldwin K, Austin MS, Mehta S. A systematic review of open reduction and internal fixation of periprosthetic femur fractures with or without allograft strut, cerclage, and locked plates. J Arthroplasty 2014;29(5):872–6.
[19] Yasen AT, Haddad FS. Periprosthetic fractures: bespoke solutions. Bone Joint J 2014;96-B(11 Supple A):48–55.
[20] Capone A, Congia S, Civinini R, Marongiu G. Periprosthetic fractures: epidemiology and current treatment. Clin Cases Miner Bone Metab 2017;14(2):189–96.
[21] Baum C, Leimbacher M, Kriechling P, Platz A, Cadosch D. Treatment of Periprosthetic Femoral Fractures Vancouver Type B2: Revision Arthroplasty Versus Open Reduction and Internal Fixation With Locking Compression Plate. Geriatr Orthop Surg Rehabil 2019;10:2151459319876859.
[22] Stoffel K, Blauth M, Joeris A, Blumenthal A, Rometsch E. Fracture fixation versus revision arthroplasty in Vancouver type B2 and B3 periprosthetic femoral fractures: a systematic review. Arch Orthop Trauma Surg 2020.
[23] Yasen AT, Haddad FS. The management of type B1 periprosthetic femoral fractures: when to fix and when to revise. Int Orthop 2015;39(9):1873–9.
[24] Marsh JL, Slongo TF, Agel J, et al. Fracture and dislocation classification compendium - 2007: Orthopaedic Trauma Association classification, database and outcomes committee. J Orthop Trauma 2007;21(10 Suppl):S1–133.
[25] Masri BA, Meek RM, Duncan CP. Periprosthetic fractures evaluation and treatment. Clin Orthop Relat Res 2004(420):80–95.
[26] Rayan F, Dodd M, Haddad FS. European validation of the Vancouver classification of periprosthetic proximal femoral fractures. J Bone Joint Surg Br 2008;90(12):1576–9.
[27] Brady OH, Garbuz DS, Masri BA, Duncan CP. The reliability and validity of the Vancouver classification of femoral fractures after hip replacement. J Arthroplasty 2000;15(1):59–62.
[28] Bhattacharyya T, Chang D, Meigs JB, Estok DM, Malchau H. Mortality after periprosthetic fracture of the femur. JBJS 2007;89(12):2658–62.
[29] Franklin J, Malchau H. Risk factors for periprosthetic femoral fracture. Injury 2007;38(6):655–60.
[30] Anakwe RE, Aitken SA, Khan LA. Osteoporotic periprosthetic fractures of the femur in elderly patients: outcome after fixation with the LISS plate. Injury 2008;39(10):1191–7.
[31] Young SW, Walker CG, Pitto RP. Functional outcome of femoral peri prosthetic fracture and revision hip arthroplasty: a matched-pair study from the New Zealand Registry. Acta Orthop 2008;79(4):483–8.
[32] El-Zayat B, Ruchholtz S, Efe T, et al. NCB-plating in the treatment of geriatric and periprosthetic femoral fractures. Orthopaedics & Traumatology: Surgery & Research 2012;98(7):765–72.
[33] Ruchholtz S, El-Zayat B, Kreslo D, et al. Less invasive polyaxial locking plate fixation in periprosthetic and peri-implant fractures of the femur—a prospective study of 41 patients. Injury 2013;44(2):239–48.
[34] Hoffmann MF, Lotzien S, Schildhauer TA. Outcome of periprosthetic femoral fractures following total hip replacement treated with polyaxial locking plate. Eur J Orthop Surg Traumatol 2017;27(1):107–12.
[35] Soenen M, Baracchi M, De Corte R, Labey L, Innocenti B. Stemmed TKA in a Femur With a Total Hip Arthroplasty: Is There a Safe Distance Between the Stem Tips? The Journal of Arthroplasty 2013;28(8):1437–45.
[36] Mont MA, Maar DC. Fractures of the ipsilateral femur after hip arthroplasty: A statistical analysis of outcome based on 487 patients. The Journal of Arthroplasty 1994;9(5):511–19.
[37] Moore RE, Baldwin K, Austin MS, Mehta S. A Systematic Review of Open Reduction and Internal Fixation of Periprosthetic Femur Fractures With or Without Allograft Strut, Cerclage, and Locked Plates. The Journal of Arthroplasty 2014;29(5):872–6.
[38] Perren SM, Fernandez Dell'oca A, Regazzoni P. Fracture Fixation Using Cerclage, Research Applied to Surgery. Acta Chir Orthop Traumatol Cech 2015;82(6):389–97.
[39] Angelini A, Battiato C. Past and present of the use of cerclage wires in orthopedics. Eur J Orthop Surg Traumatol 2015;25(4):623–35.
[40] Khashan M, Amar E, Drexler M, Chechik O, Cohen Z, Steinberg EL. Superior outcome of strut allograft-augmented plate fixation for the treatment of periprosthetic fractures around a stable femoral stem. Injury 2013;44(11):1556–60.