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Research Article

Early Unrestricted Weight-Bearing Using a Minimally Invasive "Span the Whole Femur" Technique for Periprosthetic Femoral Fractures

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Abstract

Background: Management of periprosthetic hip and knee fractures is challenging and is becoming more frequent due to an increasing population of arthroplasty patients. These injuries lead to considerable morbidity due to loss of fixation of the components, loss of bone stock, and subsequent functional deficits. They also lead to increased mortality and their management is associated with significant risk of complications. Various management options have been described in current literature to treat periprosthetic fractures.

Aim of the Study: The aim of this study is to demonstrate that a minimally invasive [MIS] "span the whole femur" surgical technique, used across all fracture types and hip and knee periprosthetic fractures, provides predictable clinical outcomes in a challenging patient cohort.

Material and Methods: This retrospective case series reviewed patients with periprosthetic femoral fractures managed by a single surgeon at a high-volume hospital between 2019 and 2022. All patients underwent operative fixation using a minimally invasive "span the whole femur" technique, and full and unrestricted weight-bearing was permitted postoperatively in all cases. Fracture patterns included periprosthetic fractures around hip and knee arthroplasties, interprosthetic fractures involving both hip and knee implants, and revision periprosthetic fracture fixation. In all cases, fixation was performed using the NCB® Zimmer Biomet Periprosthetic Femur Plate System. Patient demographic characteristics, intraoperative variables, and postoperative clinical and radiological outcomes were collected and analysed.

Results: Fifteen patients were included, with a mean age of 83 years (range 68-93). All fractures resulted from low-energy falls. All patients were allowed immediate unrestricted weight-bearing and were mobilised within 24 hours postoperatively. Radiological and clinical union was achieved in all patients within 12 months. One superficial wound infection occurred, with no deep infection or venous thromboembolism. Thirty-day mortality was 6.7%, and all surviving patients returned to their pre-injury place of residence.

Conclusion: The span the whole femur technique is a reliable method of treating complex periprosthetic fracture with predictable radiological and clinical outcomes. This technique allows early-unrestricted weight bearing, which may reduce postoperative complications.

Level of Evidence: IV.

Keywords: *Periprosthetic Facture; Hip; Knee; Trauma; Fracture; Femur, Plating; Minimally Invasive Technique*

Introduction

Periprosthetic fractures [PPFs] are fractures associated with a prosthesis that is usually used in fracture fixation or joint arthroplasty. PFFs commonly result from low energy trauma with various risk factors that can contribute to this type of fracture; high activity levels, age, female gender, and relevant medical history that can effect bone quality [1].

The incidence of hip and knee PPFs has been increasing and they pose a challenge in any trauma list [2-4]. Berry., *et al*. reported an overall incidence after Total Hip Arthroplasty [THA] of 0.1% to 6% [5] and Rorabeck., *et al*. reported incidence of periprosthetic fracture ratios from 0.3% to 5.5% after Total Knee Arthroplasty [TKA] [6]. These fractures are associated with an increased risk or morbidity and mortality, including infection and re-operation [7]. Furthermore, post-operative outcomes for patients treated for PPFs demonstrate poor functional outcomes, particularly in regards to mobility and these fractures are associated with financial costs related to implant care, length of stay and complications [8,9].

Poor bone quality in these patients adds complexity to the suitable methods of fixation and impedes the fracture healing process [2]. The goals of fracture fixation include reduction of the fracture, ensuring the restoration of alignment, length and rotation, a stable fixation that permits early mobilisation and providing a suitable mechanical environment that enhances early fracture union. Unrestricted early weight-bearing is recommended for early mobilisation and improves functional mobility and likelihood of discharge to the original accommodation [10-14]. This has been evidenced by studies that have demonstrated the complications immobilisation and non-weightbearing can have on this population, demonstrating the need for fixations that provide an early return to full weight-bearing [15]. However, there is still apprehension in allowing full weightbearing of these patients [16-19].

There are several classification systems for periprosthetic fractures. Recently, the Unified Classification System [UCS] has incorporated different types of these fractures in one classification system, which is based on the fracture location with regards to the implant, and it considers the stability of the implant and the bone stock quality in the type B [20]. In the literature manuscripts have looked at further factors to help provide treatment algorithms for the management of these injuries, including taking patient history, stem design, and plain radiographs into consideration [21]. A recent systematic review concluded that the evidence base of reported surgical management outcomes is generally substandard and does not entail treatment recommendations [2]. Despite this, the use of locking plates, in particular the NCB plate has been shown, to be a useful tool in the management of periprosthetic fractures ensuring the femur if fixed along its full length, also known as a 'span the femur' technique, has been recommended along with soft tissue preserving techniques [23].

Aim of the Study

The aim of this study is to demonstrate that a minimally invasive [MIS] "span the whole femur" surgical technique, used across all fracture types and hip and knee periprosthetic fractures, provides predictable clinical outcomes in a challenging patient cohort.

Materials and Methods

This paper details a surgical technique of the minimally invasive [MIS] "span the whole femur" surgical technique, managed by a single surgeon admitted to a high-volume trauma district general hospital between 2019-2022.

In this hospital, a dedicated, high volume, fellowship trained, consultant trauma and orthopaedic surgeon with expertise in complex trauma and revision lower limb arthroplasty treats periprosthetic fractures. Cases were discussed pre-operatively at a regional multidisciplinary team [MDT] network meeting with a collective decision made to fix rather than use a prosthetic replacement base. All cases were undertaken using an MIS technique with a NCB Zimmer plate used in a 'span the whole femur' technique.

Pre-operative, intraoperative, and post-operative data were prospectively collected from a comprehensive electronic database. Recorded variables included patient demographics [age, sex], medical comorbidities, fracture characteristics, and the presence and type

of any pre-existing implants. Operative details included estimated blood loss, time to surgery, and duration of the surgical procedure were documented. Post-operative outcomes included length of hospital stay, return to original accommodation, duration of clinical and radiographic follow-up, and time to fracture union.

Patient follow-up was routinely scheduled at 2 weeks, 6 weeks, 3 months, and 6 months postoperatively, with additional reviews performed thereafter as required until both radiological and clinical union of the fracture were achieved. Fracture union was defined radiographically by the presence of bridging callus across a minimum of two cortices on both anteroposterior and lateral plain radiographs, and clinically by the ability to weight-bear without pain at the fracture site. Postoperative complications were prospectively recorded and included surgical site infection, deep vein thrombosis, hardware or implant-related complications, and mortality. All patients were followed longitudinally until definitive radiological and clinical union was confirmed.

Operative details and surgical technique

All cases were performed under either regional or general anaesthesia, the patient was positioned supine on a radiolucent operating table to allow unrestricted fluoroscopic imaging. A sandbag was placed beneath the ipsilateral hemipelvis to facilitate optimal access and fluoroscopic visualisation for the insertion of per-trochanteric or femoral neck screws when required. The groin was isolated using a sterile U-drape, following which the entire hip and lower limb were prepared and draped in the standard sterile fashion.

A knee-positioning triangle was placed beneath the knee to reduce the posterior pull of the gastrocnemius muscle, thereby improving alignment in the sagittal [lateral] plane. Closed reduction of the fracture was initially attempted under fluoroscopic guidance. In cases where an acceptable reduction could not be achieved, a limited open approach was performed either proximally or distally, depending on the fracture configuration and the type of femoral plate used [proximal or distal femoral plate].

The plate was first anatomically secured to the bone at either the proximal or distal segment using non-locking screws to establish correct plate positioning. Indirect fracture reduction was then achieved using a minimally invasive surgical [MIS] biological fixation technique, allowing restoration of alignment, length, and rotation while preserving the fracture biology. Once satisfactory reduction was confirmed fluoroscopically, the fracture was stabilised by sequential fixation of the plate proximally and distally, initially with non-locking screws followed by the insertion of locking screws to complete the construct.

In selected cases, cerclage cables were utilised as an adjunct to fixation to enhance construct stability and to secure large butterfly fragments, facilitating direct bone-to-bone contact and improving the mechanical environment for fracture union.

NCB plating system

The NCB® Prosthetic Femur Plate System was used in all cases. This system, manufactured by Zimmer Biomet, consists of a range of anatomically contoured, polyaxial locking plates specifically designed for the management of periprosthetic femoral fractures. The polyaxial screw design allows flexible screw trajectory to optimise fixation around existing implants while maintaining angular stability of the construct [24].

Postoperative rehabilitation

Postoperative rehabilitation was initiated in all patients immediately following surgery as part of a standardised hospital protocol. All patients were reviewed and assessed by a specialist physiotherapist within 24 hours of the operative procedure to evaluate baseline mobility, pain control, and functional status. Early mobilisation was actively encouraged, with patients commencing bed exercises and progressive ambulation as tolerated. Full and unrestricted weight-bearing was permitted in all cases, reflecting the stability of the fixation construct, with the aim of facilitating early functional recovery, reducing complications associated with prolonged immobilisation, and promoting a return to pre-injury levels of mobility and independence.

Ethical considerations

This project meets the Health Research Authority (HRA) criteria for a service evaluation. All activities fall within the scope of direct clinical care, using information already collected for the purpose of supporting patient treatment. The project was registered with the hospital's audit department, and was conducted in accordance with the Declaration of Helsinki and the guidelines for Good Clinical Practice.

Results

A total of fifteen patients were included in this study. The cohort was predominantly female, with 13 patients [87%] female and 2 patients [13%] male. The mean age at the time of injury was 83 years, with an age range of 68 to 93 years. All fractures occurred as a result of low-energy mechanisms, specifically simple falls from standing height, consistent with fragility-type injuries commonly seen in this demographic.

Patient Demographics	N
Gender	13 Females: 2 Males
Average age [SD]	83 [7.34]
Average Abbreviated mental test score [AMTS]:	8.47
Median AMTS:	9
Median ASA	3
Place of residence at the time of the injury:	Own Home: 13 Nursing home: 2
Type of fracture	Type C - Above the femoral implant of a knee replacement: 5 Type D fracture: 7 B1 fracture: 2 B1 revision: 1

Table 1: *Illustrates the patient demographics for the whole cohort. The data displayed includes age, Abbreviated Mental Test Score [AMTS], American Society of Anaesthesiologists' [ASA] classification, place of residence and classification of the fracture.*

Intra-operative data

The mean operative time was 80 minutes [range, 47 - 120 minutes]. The median number of screws inserted per construct was 13 [range, 9 - 20]. There was a single intraoperative complication recorded where the tip of the drill was broken and was later found in the knee joint during a clinical review.

The mean preoperative haemoglobin level was 100.7 g/L [SD 26.9], which decreased to a mean postoperative level of 84.5 g/L [SD 22.8]. The mean estimated intraoperative blood loss was 293 mL [range, 150 - 600 mL]. Of the 15 patients, two required transfusion of one unit of packed red blood cells, while six patients required two units.

Post-operative data

A physiotherapist assessed all patients within 24 hours of the operative procedure. Full and unrestricted weight bearing was permitted postoperatively in all cases, as tolerated. All patients were discharged with full and unrestricted weight bearing. The average length of inpatient stay for this cohort was 27 days with a range 10 to 45 days.

Of the 15 patients, only one [6.67%] patient died within 30 days. All the other patients returned back to their original place of residence either their own home or nursing home.

Postoperatively, one patient developed a superficial surgical site infection, which was successfully managed with a single course of oral antibiotic therapy. No cases of deep infection and Venous Thromboembolism [VTE] were reported.

Radiological and clinical union was achieved in all patients within 12 months of surgery and follow-up was stopped at this time-point.

Discussion

The incidence of periprosthetic fractures [PPFs] continues to rise and represents a significant treatment challenge, particularly in an ageing population with reduced bone stock who may sustain fractures following low-energy mechanisms of injury [2-4]. These patients frequently present with complex medical comorbidities, and postoperative recovery and rehabilitation can be prolonged. The requirement for restricted or partial weight-bearing following surgery is a well-recognised factor contributing to delayed functional recovery and poorer outcomes [7,8,15]. Consequently, achieving stable fixation that permits early mobilisation remains a key objective in the management of these injuries.

Management of PPFs is inherently complex and often necessitates a multidisciplinary approach combining advanced trauma and arthroplasty expertise, as highlighted in recent literature [21,25]. Although classification systems such as the Unified Classification System [UCS] have been developed to assist with operative planning, there remains considerable heterogeneity in surgical strategies and fixation constructs employed. To our knowledge, this is the first study to describe the use of a minimally invasive "span the whole femur" technique across a broad spectrum of femoral periprosthetic fractures, including fractures above total knee arthroplasty [UCS type C], UCS type D, Vancouver B1, and B1 revision fractures. A distinctive feature of our approach is the ability to allow immediate, unrestricted weight-bearing postoperatively, irrespective of fracture type.

Previous studies have demonstrated the potential effectiveness of plate fixation in periprosthetic femoral fractures but have often been associated with high complication rates or prolonged weight-bearing restrictions. Holder., *et al*. reported a case series of 63 patients managed with a combination of revision surgery and open reduction internal fixation, achieving an 82% union rate but with a serious complication rate of 31%; notably, ten patients were excluded due to intraoperative fracture or perioperative mortality [7]. Similarly, Moreta., *et al*. reported high union rates offset by significant reoperation and complication rates [8]. Wood., *et al*. described a comparable fixation strategy using compression plating in 15 patients with hip or knee arthroplasty fractures, demonstrating technical feasibility but reporting a 20% mortality rate and restricting full weight-bearing for a minimum of three months postoperatively [26]. Molinari., *et al*. also utilised a dedicated NCB plate with a two-year follow-up, reporting comparable patient demographics but excluding knee periprosthetic fractures and permitting only partial weight-bearing for the first six to eight weeks [27]. Kinov., *et al.* demonstrated fracture union in all 56 Vancouver-classified periprosthetic hip fractures, though knee periprosthetic fractures were again not included [28].

Collectively, these studies support the role of plate fixation in the management of PPFs, a finding consistent with the outcomes of our series. Erhardt., *et al*. reported promising results using NCB plate fixation in 24 patients, achieving a 90% union rate with a 15% reoperation rate, including one fatigue failure of the plate [29]. However, the authors acknowledged selective postoperative weight-bearing restrictions. In contrast, our case series permitted immediate unrestricted weight-bearing, reflecting our confidence that a whole-femur spanning construct provides sufficient stability to safely allow early mobilisation.

Broader guidelines and treatment algorithms increasingly emphasise patient-specific decision-making and multidisciplinary team involvement, both of which are reflected in our approach [21,25]. Furthermore, a recent systematic review advocated the use of open reduction and internal fixation [ORIF] for selected Vancouver B2 and B3 fractures when adequate bone stock is present, rather than routine revision arthroplasty [30]. Multiple biomechanical, clinical, and cadaveric studies have highlighted the effectiveness of NCB plates in periprosthetic fracture fixation [27,29,31]. Locking plate constructs provide relative stability while preserving periosteal blood supply and offering greater flexibility in screw placement-advantages that are particularly valuable in osteoporotic bone [32]. In addition, the

minimally invasive plate osteosynthesis [MIPO] technique preserves the soft-tissue envelope and fracture haematoma, optimising the biological environment for fracture healing, as emphasised in this study [33,34].

From a biomechanical perspective, spanning the entire femur with a long plate improves construct strength by distributing stress over a greater length, increasing the working length and reducing stress concentration at individual screw-bone interfaces [32,35]. Longer plates also minimise stress risers associated with short constructs, thereby reducing the risk of secondary fractures. These principles are especially relevant in osteoporotic bone, where increasing the moment arm of fixation decreases pull-out forces acting on individual screws [36-38].

Distinctive features of the Zimmer NCB plate include a wider proximal plate design with offset holes, allowing bicortical screw placement around existing prostheses and facilitating divergent screw trajectories. This configuration enhances construct stability while reducing the risk of cortical perforation and iatrogenic fracture. The polyaxial screw design allows angulation of up to 15° from the orthogonal plane [a 30° cone], with angular stability achieved using locking caps. This enables the combined advantages of conventional lag screw fixation and locking screw stability while preserving periosteal blood supply when used in locking or spacer-cap modes.

Biomechanical evidence supports these design advantages. In a cadaveric study comparing Vancouver B1 periprosthetic fracture fixation using NCB plates versus fixed-angle locking attachment plates, Wähnert., *et al*. demonstrated significantly greater axial stiffness and higher cycles to failure in the NCB group [39].

In our series, complete radiological and clinical union was achieved in all patients, with no cases of refracture observed during follow-up. These results are comparable to those reported by Moloney., *et al*. who achieved a 100% union rate in Vancouver B1 fractures [32], although our study expands on this by including a wider range of periprosthetic fracture patterns. The observed mortality rate in our cohort was 6%, with only one of fifteen patients dying after fracture union had been achieved. This rate is lower than previously reported mortality following internal fixation of periprosthetic femoral fractures [32,40]. This may be attributable to the minimally invasive nature of the technique, resulting in reduced blood loss and soft-tissue disruption, as well as the ability to permit immediate full weight-bearing, which may positively influence postoperative mobilisation and overall recovery.

The strengths of this study include the inclusion of multiple periprosthetic fracture types, the reproducibility of the surgical technique, and the consistent allowance of immediate unrestricted weight-bearing. Limitations include the retrospective design, small sample size, and the fact that all procedures were performed by a single surgeon using a single implant system. Nevertheless, our findings suggest that a minimally invasive whole-femur spanning fixation strategy can provide stable fixation, facilitate early-unrestricted mobilisation, and achieve high union rates in this challenging patient population.

Conclusion

This study supports the use of a minimally invasive surgical approach employing a polyaxial locking plate that spans the entire length of the femur for the management of periprosthetic femoral fractures. Given the complexity of these injuries and the significant comorbidity burden typically present in this patient population, we recommend that all cases of periprosthetic fractures be discussed within a multidisciplinary team (MDT) framework and managed using a shared decision-making approach. The "span the whole femur" technique represents a reliable method for treating complex periprosthetic fractures, demonstrating predictable radiological and clinical outcomes. Importantly, this strategy facilitates early, unrestricted weight-bearing, which may contribute to reduced postoperative complications and improved functional recovery.

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Deceleration of Competing Interest

Authors have no conflicts of interest to declare.

Bibliography

1. Lee SR., *et al*. "Impact of time to surgery from injury on postoperative infection and deep vein thrombosis in periprosthetic knee fractures". *Chinese Journal of Traumatology* 21.6 (2018): 329-332.
2. Capone A., *et al*. "Periprosthetic fractures: epidemiology and current treatment". *Clinical Cases in Mineral and Bone Metabolism* 14.2 (2017): 189-196.
3. Della Rocca GJ., *et al*. "Periprosthetic fractures: epidemiology and future projections". *Journal of Orthopaedic Trauma* 25.2 (2011): S66-S70.
4. Frenzel S., *et al*. "Periprosthetic femoral fractures: incidence, classification problems and the proposal of a modified classification scheme". *International Orthopaedics* 39.10 (2015): 1909-1920.
5. Berry DJ. "Epidemiology: hip and knee". *Orthopedic Clinics of North America* 30.2 (1999): 183-190.
6. Rorabeck CH and Taylor JW. "Periprosthetic fractures of the femur complicating total knee arthroplasty". *Orthopedic Clinics of North America* 30.2 (1999): 265-277.
7. Holder N., *et al*. "Outcomes following surgical treatment of periprosthetic femur fractures: a single centre series". *Canadian Journal of Surgery* 57.3 (2014): 209-213.
8. Moreta J., *et al*. "Functional and radiological outcome of periprosthetic femoral fractures after hip arthroplasty". *Injury* 46.2 (2015): 292-298.
9. Phillips JR., *et al*. "What is the financial cost of treating periprosthetic hip fractures?" *Injury* 42.2 (2011): 146-149.
10. Overview | Hip fracture: management | Guidance | NICE (2022).
11. BOA. BOAST - The Care of the Older or Frail Orthopaedic Trauma Patient (2022).
12. Kubiak EN., *et al*. "Early weight bearing after lower extremity fractures in adults". *Journal of the American Academy of Orthopaedic Surgeons* 21.12 (2013): 727-738.
13. Malik AT., *et al*. "Incidence, risk factors and clinical impact of postoperative delirium following open reduction and internal fixation [ORIF] for hip fractures: an analysis of 7859 patients from the ACS-NSQIP hip fracture procedure targeted database". *European Journal of Orthopaedic Surgery and Traumatology* 29.2 (2019): 435-446.
14. Baer M., *et al*. "Influence of mobilization and weight bearing on in-hospital outcome in geriatric patients with hip fractures". *SICOT-J* 5 (2019): 4.
15. Fredin HO., *et al*. "Femoral fracture following hip arthroplasty". *Acta Orthopaedica Scandinavica* 58.1 (1987): 20-22.
16. Whitehouse MR and Mehendale S. "Periprosthetic fractures around the knee: current concepts and advances in management". *Current Reviews in Musculoskeletal Medicine* 7.2 (2014): 136-144.
17. Ebraheim NA., *et al*. "High complication rate in locking plate fixation of lower periprosthetic distal femur fractures in patients with total knee arthroplasties". *Journal of Arthroplasty* 27.5 (2012): 809-813.

18. Oldmeadow LB., *et al*. "No rest for the wounded: early ambulation after hip surgery accelerates recovery". *ANZ Journal of Surgery* 76.7 (2006): 607-611.

19. Ruder JA., *et al*. "Predictors of functional recovery following periprosthetic distal femur fractures". *Journal of Arthroplasty* 32.5 (2017): 1571-1575.

20. CP Duncan and FS Haddad. "The Unified Classification System [UCS]: improving our understanding of periprosthetic fractures". *Bone and Joint Journal* 96-B.6 (2014): 713-716.

21. Stoffel K., *et al*. "Periprosthetic fractures of the proximal femur: beyond the Vancouver classification". *EFORT Open Reviews* 5.7 (2020): 449-456.

22. Stoffel K., *et al*. "The influence of the operation technique and implant used in the treatment of periprosthetic hip and Interprosthetic femur fractures: a systematic literature review of 1571 cases". *Archives of Orthopaedic and Trauma Surgery* 136.4 (2016): 553-561.

23. Konstantinidis L., *et al*. "Treatment of periprosthetic femoral fractures with two different minimal invasive angle-stable plates: Biomechanical comparison studies on cadaveric bones". *Injury* 41.12 (2010): 1256-1261.

24. https://www.zimmerbiomet.com/content/dam/zb-corporate/en/products/specialties/trauma/ncb-periprosthetic-femur-plate-system/ncbperiprostheticfemurplatesystem.pdf

25. Patsiogiannis N., *et al*. "Periprosthetic hip fractures: an update into their management and clinical outcomes". *EFORT Open Reviews* 6.1 (2021): 75-92.

26. Wood GC., *et al*. "Locking compression plates for the treatment of periprosthetic femoral fractures around well-fixed total hip and knee implants". *Journal of Arthroplasty* 26.6 (2011): 886-892.

27. Molinari GP., *et al*. "Surgical treatment of peri-prosthetic femur fractures with dedicated NCB plates: our experience". *Acta Biomedica* 91.2 (2020): 297-304.

28. Kinov P., *et al*. "Surgical treatment of periprosthetic femoral fractures following hip arthroplasty: our institutional experience". *Injury* 46.10 (2015): 1945-1950.

29. Erhardt JB., *et al*. "Treatment of periprosthetic femur fractures with the non-contact bridging plate: a new angular stable implant". *Archives of Orthopaedic and Trauma Surgery* 128.4 (2008): 409-416.

30. Stoffel K., *et al*. "Fracture fixation versus revision arthroplasty in Vancouver type B2 and B3 periprosthetic femoral fractures: a systematic review". *Archives of Orthopaedic and Trauma Surgery* 140.10 (2020): 1381-1394.

31. Stephan Brand., *et al*. "Intraprosthetic fixation techniques in the treatment of periprosthetic fractures-A biomechanical study". *World Journal of Orthopedics* 3.10 (2012): 162-166.

32. Moloney GB., *et al*. "Treatment of periprosthetic femur fractures around a well-fixed hip arthroplasty implant: span the whole bone". *Archives of Orthopaedic and Trauma Surgery* 134.1 (2014): 9-14.

33. Ruchholtz S., *et al*. "Less invasive polyaxial locking plate fixation in periprosthetic and peri-implant fractures of the femur: a prospective study of 41 patients". *Injury* 44.2 (2013): 239-248.

34. Kanakaris NK., *et al*. "Fixation of periprosthetic or osteoporotic distal femoral fractures with locking plates: a pilot randomised controlled trial". *International Orthopaedics* 43.5 (2019): 1193-1204.

35. Gautier E and Sommer C. "Guidelines for the clinical application of the LCP". *Injury* 34.2 (2003): B63-B76.

36. Rozbruch RS., *et al*. "The evolution of femoral shaft plating technique". *Clinical Orthopaedics and Related Research* 354 (1998): 195-208.

37. Beltran MJ., *et al*. "Stress modulation of fracture fixation implants". *JAAOS - Journal of the American Academy of Orthopaedic Surgeons* 24.10 (2016): 711-719.

38. Laurence M., *et al*. "Engineering considerations in the internal fixation of fractures of the tibial shaft". *The Journal of Bone and Joint Surgery British Volume* 51-B.4 (1969): 754-768.

39. Wähnert D., *et al*. "Biomechanical comparison of two angular stable plate constructions for periprosthetic femur fracture fixation". *International Orthopaedics* 38.1 (2014): 47-53.

40. Bhattacharyya T., *et al*. "Mortality after periprosthetic fracture of the femur". *The Journal of Bone and Joint Surgery American Volume* 89.12 (2007): 2658-2662.

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