CLINICAL ARTICLE

Locking Plate Fixation of Periprosthetic Femur Fractures with and without Cerclage Wires

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Objective: The number of patients requiring knee and hip arthroplasty has been steadily increasing, and periprosthetic fractures are on the rise. Locking plates are the most common treatment for periprosthetic fractures, but the use of cerclage wires with locking plate fixation has been controversial.

Methods: Forty-seven patients with periprosthetic femur fractures were reviewed retrospectively. Twenty-four patients received locking plate alone and twenty-three patients were treated with locking plate and cerclage wires. Patients were evaluated for clinical and radiographic signs of union at two, six, twelve, twenty-four, and forty-eight weeks postoperatively.

Results: The average follow-up time in the plate group was 9.4 ± 6.7 months, while it was 6.0 ± 4.2 months in the cerclage wire group. The time to union in the cerclage wire group (3.6 ± 1.0 months) was significantly less than the plate group (4.8 ± 2.6 months). The group with the cerclage wires had a significantly lower revision rate of 0% compared to 20.8%. There was no statistical significance of union rate and complication rate between the two groups.

Conclusion: Cerclage wires used with locking plate fixation successfully treats periprosthetic fractures of the femur with faster time to union, less complication, and fewer revisions.

Key words: Cerclage wires; Femur; Locking plate; Periprosthetic fractures

Introduction

Within recent decades, the number of patients requiring total knee and hip arthroplasty has been steadily increasing. In an aging population with an increased life expectancy, this will remain a trend as the efficacy of these procedures continues to increase¹. Subsequently, the number of patients sustaining a periprosthetic fracture is also increasing with the incidence rate after primary knee and hip arthroplasty amounting to 2.5%²⁻⁴. Due to a high complication rate and poor functional outcome, non operative treatment of periprosthetic femur fractures is not recommended in most cases for aged patients⁵.

Reduction and fixation of these fractures can be a challenging task. Due to the intramedullary implant in the femur, conventional non-locking plates have shown poor results with complication rates as high as 53%⁵. The advantages of locking

plates over conventional plates have made them the most common treatment of periprosthetic fractures^{6,7}. Although locking plates are recommended in most cases of periprosthetic fractures, failure rates up to 21% have been reported requiring reoperation^{2,8,9}. This complication rate is considerable for the elderly patient population with pre-existing medical comorbidities, as re-operation continues to have a negative impact on patient health.

With locking plates sometimes difficult to fix with intramedullary implants, cerclage wires have been used to provide a more stable fixation. However, the use of these wires is controversial. It has been suggested that open techniques with locking plates and cerclage wires require extensive soft tissue dissection and may lead to strangulation of periosteal vascularization, resulting in bone necrosis and nonunion^{10,11}. On the other hand, previous studies on synthetic and

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embalmed femurs have demonstrated that using a locking plate with cerclage wires has an equivalent effect on the biomechanical strength of bone as using a locking plate alone in periprosthetic fractures^{12,13}.

However, to date, little research has been done on live human patients that compare the outcomes of locking plate with or without cerclage wires on periprosthetic femur fractures. The purpose of the paper was to compare the fusion rates, time to union, complication rates, and revision rates of a locking plate with and without cerclage wires in the treatment periprosthetic femur fractures.

Materials and Methods

Study Design

After approval by our institutional review board, the authors retrospectively reviewed forty-seven patients with periprosthetic femur fractures treated with locking plate fixation. Chart review yielded two distinct treatment groups. Twenty-four patients received a locking plate alone and twenty-three patients were treated with a locking plate and cerclage wires.

Patient Demographics

The patient demographics were similar in both groups. The plate group consisted of 24 patients (16 females and 8 males) averaging 74.7 ± 10.5 years of age. Fourteen patients previously underwent total knee arthroplasty (TKA), seven patients had previous total hip arthroplasty (THA) and three patients had previous TKA and THA. There were ten periprosthetic femur fractures following THA with seven Vancouver classification B1 fractures and three Vancouver classification C fractures. Fourteen patients had periprosthetic femur fractures following TKA with eight fractures nondisplaced and six fractures displaced. One patient received a bone allograft.

The cerclage wire group consisted of 23 patients (15 females and 8 males) averaging 78.4 ± 8.8 years of age. Two patients previously underwent TKA, sixteen patients had previous THA and five patients had previous TKA and THA. There were twenty-one periprosthetic femur fractures following THA with eighteen Vancouver classification B1 fractures and three Vancouver classification C fractures. Two patients had periprosthetic femur fractures following TKA with one fracture nondisplaced and one fracture displaced. Ten patients received a bone allograft.

All fractures in the plate and cerclage wire groups had a stable prosthesis and were sustained following a low energy fall.

Surgical Technique

All patients were kept on Buck's traction at the time of admission until surgery. Once associated injuries were ruled out, comorbidities taken into account, and medical clearance obtained, patients were taken to the operating room. The average time from injury to operation was 2.6 days. Ancef was given preoperatively and for 72 hours postoperatively. Lovenox was administered preoperatively and for six weeks postoperatively in patients without a contra-indication.

The operations were performed using a lateral approach to gain access to the femoral shaft. Stability of the stem was assessed preoperatively using radiographic criteria and confirmed during surgery so as to strictly include only the fractures with stable femoral prosthesis in the study.

After the fracture was reduced under direct vision and the reduction was confirmed with image intensification, a distal femur PERI-LOC Periarticular Locked Plating System (Smith and Nephew Inc., Cordova, TN) for the contralateral side was reversed and placed on the femur. Locking screws were placed proximally in the trochanter and distally in the shaft, distal to the tip of the stem of the prosthesis. The patients received six proximal and six distal bicortical screws (Fig. 1). In addition, the cerclage wire group received a minimum of two proximal and two distal cerclage wires (Dall-Miles Cable System, Stryker Corp., Mahwah, NJ) to aid in reduction and fixation while the plate group did not. Allografts were placed in patients who had poor bone stock or a bone defect. This was done in both the plate and cerclage wire groups at the discretion of the surgeon.

Complications and Follow-up

Postoperatively, patients were allowed to sit up in bed on the day of surgery. Toe-touch weight bearing and active range of motion exercises were encouraged postoperatively. Once union was evident both clinically and radiographically, partial to full weight bearing as tolerated was encouraged.

Patients were evaluated for clinical and radiographic signs of union at two, six, twelve, twenty-four, and forty-eight weeks postoperatively and then yearly thereafter. At each follow-up, patients were evaluated for complications including infection, change in fracture alignment, delayed union, deep vein thrombosis, nonunion, and failed fixation. Excluding

Fig. 1 The placement of locking plate and a minimum of two proximal and distal Dall-Miles cables to successfully reduce and fix the periprosthetic femur fracture.

Fig. 2 Periprosthetic femur fracture in patient with total hip replacements. (a) Displays anteroposterior view preoperatively. (b) anteroposterior view and (c) axial view show postoperative views: Fracture healing well 5 months after locking plate and Dall-Miles cables successfully reducing and fixating the fracture site.

infection, deep vein thrombosis, and delayed union, patients with these complications as well as any hardware failures had to undergo revision open reduction with internal fixation (ORIF). Fracture union was defined clinically as the ability to bear weight without pain at the fracture site, and radiographically as the presence of callus bridging at least one cortex on both the anteroposterior and lateral views. *Delayed union* was defined as healing that had extended beyond six months from the time of surgery. *Nonunion* was defined as the absence of progressive signs of healing for three months after a period of six months had elapsed from the date of the surgery. *Malunion* was defined as $\geq 5^\circ$ of deformity at the fracture site on either the anteroposterior or lateral views.

Statistical Analysis

All statistics were done using Microsoft Excel 2010. Means and standard deviations were calculated for all applicable parameters. Student *t* tests were used for time to union. Chi-square tests were also conducted for union, complication, and revision rates. The significance level used was $P < 0.05$.

Results

The patients were followed up until complete fracture union and total weight bearing were achieved at minimum. The average follow-up time in the plate group was 9.4 ± 6.7 months, while it was 6.0 ± 4.2 months in the cerclage wire group. Some patients chose to continue their rehabilitation even after these goals were reached.

The fracture reduction and alignment were excellent in all patients postoperatively. The average time to achieve

fracture union and total weight bearing in patients receiving cerclage wires was 3.6 ± 1.0 months. Twenty-two out of twenty-three patients (95.7%) in the cerclage wire group achieved union. Five patients encountered post-operative complications (21.7%). The one patient that suffered a delayed union (4.3%) had severe osteoporosis and rheumatoid arthritis and sustained multiple intraoperative fractures and was referred to a specialty center for treatment. One patient had a deep vein thrombosis (4.3%), and three patients (13.0%) suffered a methicillin-resistant *Staphylococcus aureus* (MRSA) infection and underwent irrigation and debridement. There were no fixation failures or revisions in this group (Fig. 2).

The average time to achieve fracture union and total weight bearing in the plate group, which did not receive cerclage wires, was 4.8 ± 2.6 months. Twenty-three out of twenty-four patients (95.8%) achieved union in this group. Nine patients in this group encountered post-operative complications (37.5%). One patient sustained a nonunion (4.2%) and four patients suffered a failed fixation (16.7%) that required revision ORIF (20.8%, Fig. 3). Four patients (16.7%) had an MRSA infection requiring irrigation and debridement.

The time to union in the patients receiving cerclage wires was significantly less than the patients not receiving cerclage wires ($P = 0.046$). The group with the cerclage wires also had a significantly lower revision rate due to failed fixation with 0% compared to 20.8% in the group not receiving cerclage wires ($P = 0.020$). There was no statistical significance of union rate and complication rate between the two groups ($P > 0.05$).

Fig. 3 Periprosthetic femur fracture treated with locking plate. (a) After 8 months the plate failed fixation resulting in delayed union. (b) Seven months after treating with revision and allograft, the fracture is healed. (c) After 2 year follow-up, the fracture remodeled well.

Discussion

Treating periprosthetic femur fractures is a challenging task. Bone quality is usually poor due to underlying osteoporosis and stable fixation is difficult to achieve in fractures near an intramedullary implant⁶. Also, fracture healing is significantly delayed in elderly patients¹⁴.

Normally the blood supply for the femur runs from the proximal portion to the distal portion of the femur. However, after this area is fractured, the blood supply becomes inadequate, ranging from being seriously compromised to having little or no blood supply. Also, the previous total knee or hip arthroplasty may have impaired the femur's blood supply resulting in devitalization of bone and surrounding soft tissue. The blood supply is then impaired further by operative treatment to fix the fracture. Maximal preservation of the femur's blood supply is crucial for ensuring the best chances of fracture healing. These issues present surgeons with few options to achieve a successful fixation resulting in high rates of delayed union, nonunion, and fixation failure^{2,15,16}.

Locking plate devices can eliminate some of the concerns with periprosthetic femoral fractures and reduce some of the complications seen with traditional fixation methods^{6,17}. However, these studies are contradicted by others that demonstrate many complications associated with the use of locking plates alone^{2,5}.

Although advantages can be observed when the use of the locking plate is accompanied by cerclage wires, their use as an adjunct to locking plate devices has been the topic of wide spread controversy. Used in combination with the locking plate, cerclage wires are efficient at increasing stabilization,

preventing the backing out of screws, and inhibiting plate rotation¹². However, biomechanical studies have found no difference between using the locking plate alone and locking plate accompanied by cerclage wires. These biomechanical studies conducted on synthetic and embalmed femurs have demonstrated that using a locking plate with cerclage wires has an equivalent effect on the biomechanical strength of bone as locking plate alone in periprosthetic fractures^{12,13}. Although this study analyzes mechanical strength and stability, it was unable to take into account the properties of in vivo bone such as vascularization, remodeling, and bone quality that also have a large impact on periprosthetic fracture healing and may have led to differing results found in the present study.

Other studies have also suggested that open techniques with locking plates and cerclage wire may lead to a strangulation of periosteal vascularization, resulting in bone necrosis and nonunion^{10,11}. However, upon further review it was found that the extensive soft tissue dissection and stripping to expose and reduce the fracture caused the bone necrosis and other complications¹⁸. Kirby and Wilson also found no evidence of cortical devascularization with any type of cerclage wire with minimal soft tissue stripping in the femurs of six dogs¹⁹.

The current study supports these results in that the time to union in the patients receiving cerclage wire was significantly less than the patients not receiving cerclage wires. The cerclage wire group also had a significantly decreased revision rate. Of the patients that did not receive cerclage wires, one experienced nonunion and four had failed fixation requiring

revision ORIF. At the time of the original surgery in these patients it was believed that cerclage wires were not needed due to adequate bone strength and quality.

Unfortunately, in one patient, all the distal locking screws pulled away from the bone three weeks post-operatively when attempting to walk against doctor's orders before adequate healing and union had occurred. The next three patients with complications suffered a failed fixation as the locking screws and plate pulled away from the bone. The final patient had one screw back out of the locking plate six weeks post-operatively. Each one of these patients underwent revision ORIF using locking plate fixation and achieved subsequent union at an average of nine months after their original surgery. Retrospectively, it is the belief of the current authors that had these patients received cerclage wires to secure femur fixation during the original surgery, these complications could have been avoided and union achieved uneventfully. This coincides with the current study's findings that all but one patient treated with cerclage wires and a locking plate went on to

achieve union and full weight bearing within three months of surgery.

The contradiction among previous studies has led to confusion and controversy regarding the use of locking plates with and without cerclage wires. The results of the current study are reported in the hopes of amending any concerns found in previous reports. From our study, the authors determined that the main reason for failure of the locking plate was due to the lack of any accompanying cerclage wires. The combination of locking plate and cerclage wires allows the fracture to be fixed adequately, guards against plate rotation on the femur, and prevents the locking screws from backing-out.

In conclusion, the treatment of periprosthetic fractures of the femur in patients with THAs or TKAs can be extremely challenging and associated with high complication and failure rates. However, through the use of cerclage wires with locking plates, one is able to provide a more stable fixation and avoid the complications associated with revision surgeries in an elderly population.

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