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Brief communication

Treatment of periprosthetic fractures of the knee using trabecular metal cones for stabilization

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ABSTRACT

This report describes an operative technique for the treatment of periprosthetic fractures of the knee with instability of the metaphysis and the metadiaphyseal junction that stabilizes the metaphyseal fragment by a distraction technique using trabecular metal cones. Fifteen patients were examined clinically and radiologically for a follow-up period of 36.7 ± 8.7 months. The Knee Society Score improved to 73.2 ± 20.2 by 24 months after surgery; the function score improved to 68.3 ± 20.2 by 24 months after surgery. The mean flexion amounted to 94.4 ± 9.7 degrees by 24 months after surgery. The only complication was one case of thrombosis. This technique involving trabecular metal cones to stabilize metaphyseal fractures seems to represent a further option for fixation of periprosthetic fractures that are otherwise treated with megaprostheses.

Introduction

Periprosthetic fractures of the knee joint seldom occur but represent complications associated with knee arthroplasty that are difficult to treat. They are classified according to Rorabeck et al. [1] or with the new Unified Classification System [2] and occur with a frequency of up to 3% after total knee arthroplasty. They are the reason for revision surgery in about 3% of cases [3-8].

Revision surgery is necessary when the knee endoprosthesis becomes loose or when osteosynthesis is not possible because of the size of the bone defect. In the latter case, treatment has often involved megaprostheses with a metallic replacement of the distal femur or allograft replacement of the distal femur [4,8]. The disadvantage of these techniques are associated with the low level of biological reconstruction and the high risk of infection that results from the large metallic or dead bone surfaces [8-11].

Experiences with revision surgery of the hip joint have shown that instability resulting from pelvic discontinuity can be successfully treated with a distraction technique [12]. This involves stabilizing the fragments by inducing tension in the soft tissue using trabecular metal cups. Moreover, trabecular metal cones have been used successfully for treating bone defects in revision knee arthroplasty [13]. In this report, we describe a technique using trabecular metal cones for the stabilization of periprosthetic fractures of the knee joint. This technique can be used when there is instability of the metaphysis resulting from a loosened prosthesis (Rorabeck Type C, UCS Type V.3 B3 or V.4 B3 [1,2]) and fracture of the metaphysis or at the meta-diaphysis junction.

Material and methods

Surgical technique

After preparation of the diaphyseal bone with the reamers, the last reamer to be used, which has the closest contact with the bone of the diaphysis, is left in place to act as a guide for the next steps. The appropriate trabecular metal cone is then selected which will enable tensioning in the region of the metaphyseal fracture and so brings about a stabilization of the fragments (Fig. 1a-c). A provisional cone is used to check that the final cone will not interfere with the femoral component box defining the axis of the knee

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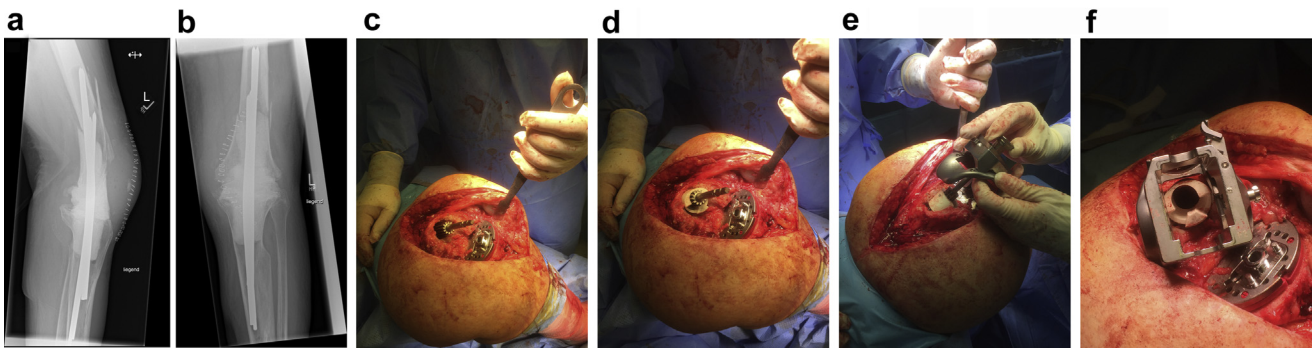

Figure 1. (a) Antero-posterior (AP) (a) and lateral (b) preoperative radiograph of the knee of an 80-year-old patient with a static spacer after removing a well-fixed, infected hinge prosthesis with long cemented stems showing fracture of the distal femur. Intraoperative photoraph after implanting the trial tibial component and positioning the femoral intramedullary reamer for alignment; note that an additional longitudinal posterior femoral fracture is seen (c). Placement of the trial trabecular metal cone of the reamer for filling the defect, and distraction osteosynthesis of the femoral longitudinal fracture (d). Positioning of the trial implant with augments to reconstruct the correct joint line (e). Placement of the trial implant to check whether box preparation interferes with the cone (f). Impacting in the chosen cone of the reamer as an alignment guide (g). Positioning of the trial implant with augments to reconstruct the correct joint line for control (h). Cementing in the final implants before combining the two components with the inlay and the axis (i,j). Postoperative AP (k) and lateral (l) radiographs at 2-year follow-up showing partially healed fractures and incorporated cones.

prosthesis. In addition, the provisional is used to check that the trial prosthesis components, with provisional augments attached as necessary, are correctly positioned and aligned according to the size and depth of the defective area (Fig. 1d and e). This is checked again after the provisional cone is replaced with the selected final cone (Fig. 1f and g). As soon as the position and fit are satisfactory and implantation of the trial components shows correct positioning, the selected final components are cemented into position (Fig. 1h-j). Thus, the site of the metaphyseal fracture is bypassed and stabilized by the stem of the prosthesis in a similar way to the technique described, for example, by Berry [14] for the treatment and stabilization of Vancouver Type B3 periprosthetic fractures of the proximal femur.

Patients

Between 2010 and 2016, a total of 15 patients (9 women and 6 men) aged 72.3 ± 7.4 years (65-85 years old) with a body mass index of 30.3 ± 5.4 (26-51) with metaphyseal instability caused by fracture of the femur (15 cases) and the tibia (4 cases) were treated with the distraction technique described previously. Every case was characterized by a longitudinal metaphyseal fracture accompanied by instability, with an additional fracture at the interface between metaphysis and diaphysis. There were six cases of loosened bicondylar total knee replacements and nine patients with a periprosthetic infection associated with a well-fixed, hinged knee prosthesis where fractures occurred during the revision procedure with removal of these hinged prostheses and implantation of a static spacer. In the latter cases, the described operative technique was initiated 6 weeks later when the static spacer was removed and a final knee prosthesis was being implanted. There were 13 patients with osteoarthritis and 2 patients with rheumatoid arthritis; the prostheses were implanted 7.9 ± 5.9 years (2-16 years) ago.

One femoral trabecular metal cone (Zimmer, Warsaw, IL) was used in 11 cases, 2 femoral cones in 3 cases, and 3 femoral cones in one case; one tibial cone was used in every case (Figs. 1k and 2a-c). A rotating hinge (11 times RHK [Zimmer, Warsaw, IL] and 4 times an Enduro [Aesculap AG, Tuttlingen, Germany]) was implanted in case, and surgery was performed by both authors who are experienced in revision knee surgery.

All patients were mobilized on the first day after surgery. Because none of them displayed a significant weakening of the extensor apparatus, they could all walk immediately with full weight-bearing capacity and according to pain levels.

The patients were examined clinically and radiologically before the implantation at 3 months, 6 months, 9 months, 12 months, 18 months, and 24 months after surgery and then at a further final examination. Radiological (X-ray in two planes) and clinical examinations were carried out at each appointment. The radiographic evaluation was conducted by comparing radiographs of the knee, in the anteroposterior view with weight bearing and in the lateral view, obtained immediately after surgery and at all subsequent follow-up examinations. The criterion used to define osseointegration of the tantalum cones was the presence of a trabecular reaction at the trabecular metal interface of the host bone, as assessed by sequential radiographs and defined by the presence of bone sclerosis together with the absence of radiolucency lines according to Mozella et al. [15] and Potter et al. [16]. During the radiographic observation, the criteria of the Knee Society's evaluation and scoring system [17], modified for long-stemmed revision

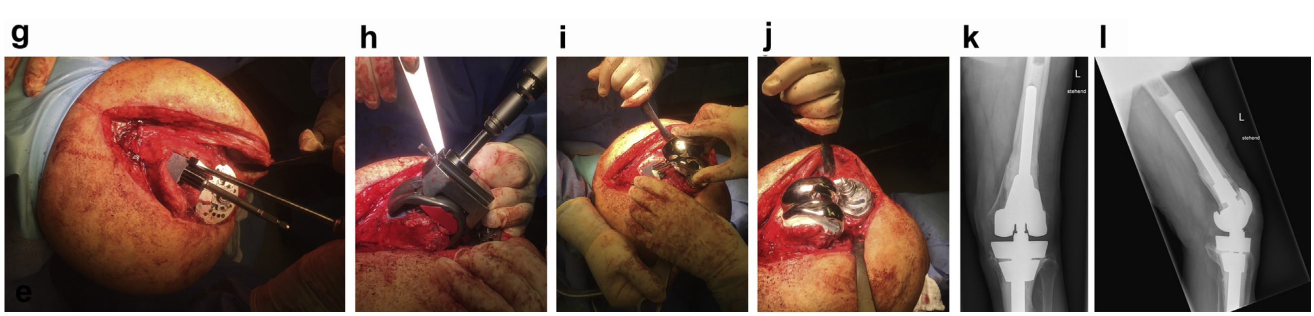

Figure 1. (*continued*).

Figure 2. Preoperative AP (a) radiograph of an infected rotating hinge prosthesis with femoral trabecular metal cone of a 65-year-old woman. AP (b) and lateral (c) radiographs of the static spacer after removal of the infected implants, with metaphyseal fractures of the femur and tibia. AP (d,e) and lateral (f,g) radiographs two years after reimplantation of a rotating hinge with distraction technique for stabilizing the metaphyseal fractures using three cones on the femoral side and one cone on the tibial side; note healed fractures and incorporated cones.

prostheses [18], were used to determine loosening or migration of prosthetic components or trabecular cones according to Mozella et al. [15], De Martino [19], and Girerd et al. [20]. Inflammation parameters (C-reactive protein) were also monitored. According to Haddad et al. [21] and Zimmerli et al. [22], a patient could be judged infection-free at follow-up if he or she was free of clinical signs for infection (high temperature, local pain, redness, warmth, sinus tract infection), had a C-reactive protein level less than 10 mg/L, and did not show any radiographic signs of osteolysis. For clinical examination the Knee Society (KS) scores were used (KS, 200 points possible) with the KS knee (100 points possible) and function (100 points possible) scores [23]. The mean follow-up period was 36.7 ± 8.7 months (between 24 and 67 months).

Results

The postoperative KSS rose continually to 73.2 ± 20.2 points 24 months after surgery; the associated function score increased to 68.3 ± 20.2 points 24 months after surgery (Table 1). Mean flexion at 24 months after surgery was 94.4 ± 9.7 degrees. There were no revisions necessary during the observation period. No reinfections occurred after a two-stage revision surgery. No evidence of loosening of the prosthesis components or of the cones was found on the radiographs, and all cones showed incorporation; similarly, there was no evidence of osteolysis. Complete bony reconstitution and union of the fracture was observed in 11 patients, whereas 4 patients showed partial reconstitution (Figs. 1j and 2c). There was one occurrence of deep vein thrombosis in the lower leg, and this was successfully treated with low-molecular-weight heparin.

Discussion

The operative technique outlined in this report gave reproducibly good results in cases of metaphyseal instability caused by longitudinal fractures in that area and additional fractures at the meta-diaphysis junction. The described operative technique is a combination of two techniques. On the one hand, a degree of stabilization of the metaphyseal fracture fragments was achieved with

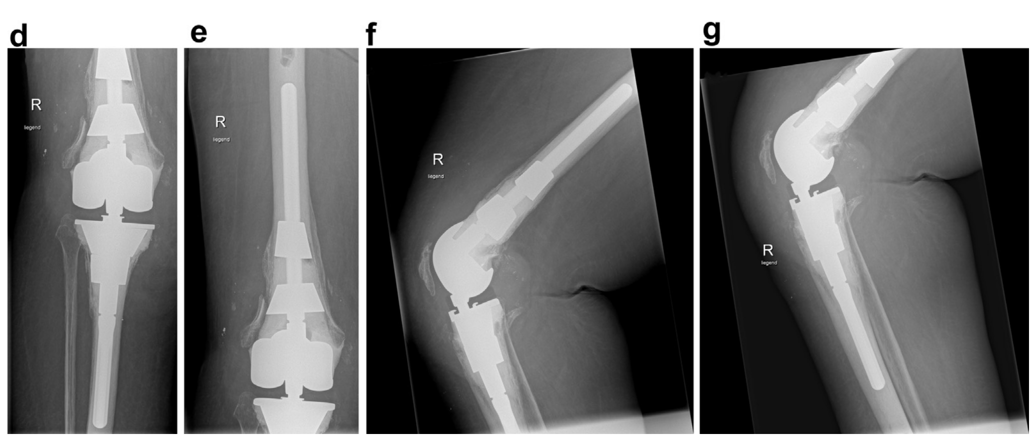

Figure 2. (*continued*).

Table 1
Knee Society knee scores, function scores, and range of motion.

Parameter	Points
Knee score 3 months after operation	46.3 ± 16.3
Knee score 6 months after operation	59.8 ± 18.8
Knee score 9 months after operation	61.5 ± 17.3
Knee score 12 months after operation	67.9 ± 15.3
Knee score 18 months after operation	70.7 ± 19.5
Knee score 24 months after operation	73.2 ± 20.2
Function score 3 months after operation	43.2 ± 21.8
Function score 6 months after operation	56.4 ± 23.2
Function score 9 months after operation	59.3 ± 22.9
Function score 12 months after operation	62.3 ± 21.8
Function score 18 months after operation	66.2 ± 23.6
Function score 24 months after operation	68.3 ± 20.2
Flexion 24 months after operation (°)	94.4 ± 9.7

the trabecular metal cones, which was similar to that described for the distraction technique applied to pelvic discontinuity. On the other hand, the bypassing of the fracture area by the stem of the prosthesis led to a level of stability similar to that reported for the treatment of Vancouver Type B3 periprosthetic fractures of the proximal femur [12,14].

However, the study has limitations. The patient group is small and nonuniform: Periprosthetic fractures and fractures that occurred during the removal of an infected hinged prosthesis, which were temporarily stabilized with a static spacer, are both included in the study. However, because this is a very rare problem, and the operative challenge of fragment instability and operative technique of stabilization were the same in all cases, these patients could be grouped together for our investigation. The fact that our study concerned a very rare constellation of periprosthetic fractures of the knee joint meant that the number of patients studied was understandably low. Comparative, randomized studies with megaprostheses or allograft reconstructions as treatment alternatives are for that reason more or less impossible to design. In addition, the variability within the individual fracture and defect situations also makes comparative studies unlikely. Thus, comparisons on alternative treatments with megaprostheses are limited and can only be based on the results of other published studies.

One advantage of the technique described here is the salvage of the bone and soft tissue structures, which lends a more biological basis to the therapy than an alternative such as megaprostheses. This is a possible reason for the low infection rate during our study (0%). Höll et al. [24] recorded an infection rate of 28% in a cohort of 20 patients treated with megaprostheses; similarly, Utting et al. [25] reported an infection rate of 20% in a group of 30 patients. Windhager et al. [8] carried out a meta-analysis of 144 megaprostheses in the treatment of periprosthetic fractures and identified a revision rate of up to 55%, with periprosthetic infection as the principal reason for the revision surgery. In total, they also reported mortality between 6.6% after one year and 45% after 34 months of follow-up.

Rahman et al. [26] reported a KSS of 67.2 after 34 months in a study of 17 cases of distal femoral replacement in the treatment for periprosthetic fractures. Mortazavi et al. [27] reported a KSS of 82.8 points after a mean follow-up of 59 months in a study of 22 knee joints, and Berend et al. [28] reported a score of 87 points after a mean period of 46 months in a study of 37 patients. Höll et al. [24] followed up on 21 knee joints over a mean period of 34 months and found a KSS of 68 points. Thus, the clinical outcomes with a KSS of 73.2 ± 20.2 points, after the technique described in this report, are comparable to the results reported by others with megaprostheses. It should also be remembered that our cohort included 9 patients who were treated with a static spacer for 6 weeks before the final revision and fracture stabilization were carried out. These patients would be expected to exhibit poorer clinical results than patients who did not have temporary joint-stiffening procedures carried out [29,30]. Furthermore, the mean flexion of 94 degrees found in our study is similar to the 83.4 degrees reported by Utting et al. [25] and 88 degrees reported by Höll et al. [24] using megaprostheses.

Conclusions

Despite the limitations, it seems that the operative technique described here results in clinical outcomes that are comparable to the clinical scores achieved with megaprostheses and thus represents an additional therapeutic option for those periprosthetic fractures that are particularly difficult to treat satisfactorily. Further studies with a larger number of patients and a longer follow-up period will provide more information about the value of this technique in the orthopedic surgeon's armamentarium.

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