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Use of locking plates in the fixation of pathologic fractures or impending pathologic fractures due to bone metastasis: a preliminary study

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Summary. *Aims:* Pathologic fractures are typically more complicated to treat than traumatic fractures because of the need for extensive reconstruction Locking compression plates facilitate superior fixation of many different types of fractures compared with standard fixation. Several reports have been published concerning the use of locking plates for the fixation of pathologic fractures caused by (predominately) primary bone sarcomas. We report our preliminary experience using locking plates for treating pathologic fractures and impending pathologic fractures secondary to bone metastasis. *Methods:* Ten patients (4 males, 6 females; mean age = 65.5 ± 14.7 years) with 11 pathological fractures (n = 6) or impending pathological fractures (n = 4) due to bone metastasis underwent tumour resection and fixation with locking plates. Fixation was performed on the distal femur (n = 7), and proximal humerus (n = 4). Breast cancer and colorectal cancer were the most common primary cancer (8/11: 72.7%). Mean follow-up was 26.3 ± 4.7 months. *Results:* Nine constructs (82%) were intact at the time of last follow-up. Two patients required a second surgical procedure, one of which was implant-related. Implant failure occurred in 2 cases; 1 because of plate breakage and the other one because of screw pull out. The cases of implant failure were successfully treated conservatively and with repeat fixation. *Conclusions:* In this preliminary study, we found that use of locking plates for fixation of pathologic fractures and impending pathologic fracture due to bone metastasis was associated with a low rate of implant failure. Further studies, including a larger number of patients, are needed to determine whether locking plates are effective for fixing pathological fractures and impending pathological fractures secondary to bone metastasis.

Key words: pathologic fracture, metastases, bone

«UTILIZZO DI PLACCHE DI BLOCCAGGIO NELLA FISSAZIONE DI FRATTURE PATOLOGICHE ACCERTATE O PREVEDIBILI DOVUTE A METASTASI OSSEE: STUDIO PRELIMINARE»

Riassunto. *Scopi:* Le fratture patologiche sono maggiormente complicate, rispetto alle fratture traumatiche, in quanto necessitano di una più vasta ricostruzione. Quando paragonato alla fissazione standard, l'impiego di placche di bloccaggio a compressione facilita la fissazione superiore di diversi tipi di fratture. Sono stati pubblicati diversi resoconti sull'uso delle placche di bloccaggio per la fissazione delle fratture patologiche causate (prevalentemente) da sarcomi ossei primari. Riportiamo qui la nostra esperienza preliminare nell'utilizzo delle placche di bloccaggio per il trattamento delle fratture patologiche accertate o prevedibili dovute alle metastasi ossee. *Metodi:* Dieci pazienti (4 maschi, 6 femmine; età media=65,5 ± 14,7 anni) con 11 fratture patolo-

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giche accertate (n = 6) o prevedibili (n = 4) dovute a metastasi ossee, sono stati sottoposti alla resezione del tumore ed alla fissazione con placche di bloccaggio. La fissazione è stata eseguita sul femore distale (n = 7), e sull'omero prossimale (n = 4). Il cancro al seno ed il cancro colorettale erano i tumori primari più comuni (8/11: 72,7%). Il follow-up medio è stato di 26,3 ± 4,7 mesi. *Risultati:* Nove impianti (82%) erano ancora intatti al momento dell'ultimo follow-up. Due pazienti hanno avuto bisogno di un secondo intervento chirurgico, uno dei quali è stato corredato da impianto. L'impianto è fallito in due casi; uno a causa della rottura della placca e l'altro a causa del distaccamento della vite. I casi di fallimento dell'impianto sono stati trattati con successo tramite metodo conservativo nuova fissazione. *Conclusioni:* In questo studio preliminare abbiamo riscontrato che l'utilizzo di placche di bloccaggio per la fissazione di fratture patologiche accertate e prevedibili dovute a metastasi ossee è collegato ad un basso tasso di fallimento dell'impianto. Sono certamente necessari ulteriori studi che includano un maggior numero di pazienti, per poter comprendere se le placche di bloccaggio sono efficaci per fissare le fratture patologiche accertate e prevedibili conseguenti a metastasi ossee.

Parole chiave: frattura patologica, metastasi, ossa

Background

Bone metastasis is a common occurrence in primary malignancy. Indeed, reports suggest that up to 50% of patients with a primary malignancy will experience bone metastasis, most often in the long bones such as the femur (1). A common complication of bone metastasis is pathologic fracture (2), which has been reported to occur in up to 29% of patients with bone metastasis (2, 3). Treatment of these pathologic fractures is essential for relieving pain, preserving limb function, and improving quality of life.

Pathologic fractures are typically more complicated to treat than traumatic fractures because of the need for extensive reconstruction (due to the removal of malignant tissue), poor bone quality, and impaired bone healing, which may be exacerbated by chemotherapy and radiotherapy (4). Moreover, for this reason, prophylactic fixation is often performed in patients with bone metastasis and impending pathologic fracture (1). Various treatment approaches have been described for treating pathologic fractures associated with bone metastasis (1, 4). Although these approaches may be effective (1, 4), continued investigation into alternative approaches/techniques is warranted to optimise outcomes.

Locking compression plates facilitate superior fixation of many different types of fractures compared with standard fixation (5). In the last 5 years, several reports have been published concerning the use of locking plates for the fixation of pathologic fractures caused by (predominately) primary bone sarcomas (6-8). In one of these reports, the authors found that patients who received fixation with locking plates had an increased rate of bony union and fewer additional procedures compared with patients who received standard compression plate fixation (6). In a recent publication, Siegel and colleagues reported on the use of locking plates in the treatment of humeral pathologic fractures due to bone metastasis, myeloma, and primary bone tumours (9). No study to date has focused solely on the use of locking plates for treating different types of pathologic fractures and impending pathologic fracture due to bone metastasis. Herein, we report our preliminary experience, including outcomes and complications, of using locking plates for the treatment of non-sarcomatous-related pathologic fracture (femur, humerus, and radius) and impending pathologic fracture caused by bone metastasis.

Methods

Patients

The medical records of all patients who had pathologic fracture or impending pathologic fracture due to bone metastasis and were treated with locking

plates from July 2007 to July 2009 were examined. Pathologic fractures were defined as fractures caused by tumour cells, whereas impeding pathologic fractures were defined as bone tumour lesions with a Mirels score ≥ 9 (10). Patients who were followed up for less than 6 months were excluded from our study. For each patient, the location of metastasis, operative procedure(s), complication(s), and treatment outcome (implant failure or implant intact) were recorded.

Surgery

All operations were performed by the same surgeon as soon as possible after diagnosis, patient condition permitting. Surgery included open fracture reduction (for displaced pathologic fractures), tumour curettage, ethanol application (11), bone cement augmentation (regular poly[methyl methacrylate] was used), and locking plate fixation. Precontoured (anatomic) Zimmer periarticular locking plates (Zimmer Inc., Warsaw, IN) were used in all cases. After surgery, operated proximal humeri were protected with a triangular sling for 2 weeks. Thereafter, gentle mobilisation was allowed as tolerated. All patients received an entire course of postoperative radiotherapy; beginning approximately 2 weeks after the removal of sutures. For surgery involving the distal femur and radius, splint protection was applied for 2 weeks. Thereafter, free range of motion and full weight bearing exercise was allowed.

Follow-up radiographs were obtained every 4 weeks for the first 6 months after surgery, and thereafter every 2 months. Radiographs were reviewed by a single surgeon and radiologist for assessment of implant position, tumour recurrence, cement position, and implant failure.

Results

A total of 17 patients received treatment with locking plates for 19 pathologic fractures due to bone metastasis at our institution between July 2007 and July 2009. Seven of these patients were excluded from the study because the follow-up period was less than 6 months. In addition, 2 patients with giant cell tumors were also excluded from the study cohort. Hence 10 patients with 11 fractures were included in the study.

The patients' overall and individual demographic and clinical characteristics are summarised in Tables 1 and 2, respectively. Almost two-thirds of the patients were female, while the mean length of follow-up was slightly over 2 years. Slightly more than half of the procedures were for fracture fixation, while the remaining 5 procedures were prophylactic fixation for impending pathologic fractures. Most (54.5%) procedures involved fixation of the distal femur, followed by the proximal humerus, and distal radius. Breast cancer and colorectal cancer were the most common form of primary cancer. A total of 9 of 11 (82%) constructs were intact at final follow-up.

One patient (Case number 6) underwent superficial infection 2 weeks after operation and required multiple debridement sessions after which she recovered smoothly. The primary implant remained structurally intact.

Table 1. Summary of overall demographic and clinical data for patients who were treated with locking plates for pathologic fractures or impending pathologic fractures secondary to bone metastasis

Characteristic	
Number of patients	**10**
Age (years), mean ± SD (range)	65.5 ± 14.7 (39, 83)
Gender, n (%)	
Male	4 (40.0)
Female	6 (60.0)
Follow-up (months), mean ± SD (range)	26.3 ± 4.7 (20, 38)
Number of pathological fractures	**10**
Type of fixation, n (%)	(45.4)
Prophylactic fixation	5 (36.4)
Fracture fixation	6 (54.5)
Location, n (%)	
Distal femur	7 (63.6)
Proximal humerus	4 (36.4)
Primary cancer, n (%)	
Breast	4 (36.4)
Prostate	1 (9.1)
Lung	2 (18.2)
Colorectal	4 (36.4)
Construct intact at final follow-up, n (%)	9 (81.8)
Second operation, n (%)	2 (18.2)
Implant failure, n (%)	2 (18.2)

SD: standard deviation

Table 2. Summary of individual demographic and clinical data for patients who were treated with locking plates for pathologic fractures or impending pathologic fractures secondary to bone metastasis

Case No	Primary cancer	Age (years)	Sex	Prophylactic fixation	Fracture	Location	Follow-up (months)	Implant failure
1	Breast	47	Female	-	+	Rt distal femur	24	
2	Prostate	76	Male	+	-	Rt proximal humerus	24	
3	Lung	59	Male	+	-	Lt distal femur	24	+
6	Breast	39	Female	-	+	Lt distal femur	28	
7	Lung	60	Male	-	+	Lt proximal humerus	26	
9	Breast	62	Female	-	+	Lt distal femur	25	
11	Colorectal	73	Female	-	+	Rt distal femur	27	
12	Breast	83	Female	+	-	Lt distal femur	27	
13	Colorectal	75	Female	-	+	Lt proximal humerus	20	+
14	Colorectal	81	Male	+	-	Rt distal humerus, Rt proximal humerus	38	

Lt: left; Rt: right

Two reports of implant failure due to plate breakage and screw pull-out were recorded. The plate breakage occurred 8 months after surgery in a patient (case number 3) who had a distal femur metastatic lesion and was treated with re-fixation using a longer plate. The screw pull-out occurred 6 months after surgery in a patient (case number 13) who had a proximal humeral metastatic lesion. The most proximal locking screw on the plate partially pulled out after the patient suffered a fall braced with an outstretched arm. The patient refused further surgery and successfully recovered with conservative treatment.

Radiographs from 1 representative case are shown in Figure 1.

Discussion

We have reported our preliminary experience using locking plates for fixation of pathologic fractures and impending pathologic fractures due to bone metastasis. After a more than 2 years median follow-up, we found that 81.8% of implants inserted for fixation of distal femur, proximal humerus, and distal radius pathologic fractures and impending pathologic fracture were intact. Our preliminary findings suggest that locking plates may be a viable option for fixation of pathologic fractures and impending pathologic fractures due to bone metastasis.

Locking plates have been widely used in the fixation of different types of fractures and show specific indication for nonunion and fixation of osteoporotic bones (12-14). Locking plates provide a fixed-angled construct which provides better screw purchase in poor bone quality and decreases screw pull-out, particularly with bone cement augmentation (15, 16). Although locking plates have traditionally been used for indirect fracture reduction, diaphyseal or metaphyseal fractures in osteoporotic bone, and for bridging severely comminuted fractures (5, 6), a number of reports in recent years on the use of locking plates in the treatment of pathologic fractures caused by primary bone tumours or bone metastasis have been recorded (6-9).

In the present study we found that 81.8% (9/11) of implanted locking plates were intact in patients treated for impending pathologic fracture or pathologic fracture of the distal femur, proximal humerus, or distal radius due to bone metastasis. Our rate of implant failure (18.2%) is similar or slightly higher than rates [0% (9), 8% (7), 10% (8), and 25% (6)] reported in previous studies involving the use of locking plates for fixation of pathologic fractures and is comparable to the rate of implant failure (11%) reported in a previous study involving the use of cement with non-locking plates for fixation of pathologic humeral fractures (17). It should be observed that our study is the only one in the literature

Figure 1. Radiographs from a 59 year-old male with lung cancer who suffered bone metastasis. (A, B) Plain radiographs revealed the presence of an osteolytic lesion (arrow) in the left distal femur. (C) Curettage, bone cement augmentation, and fixation with a locking periarticular plate (arrows) were performed. (D) The patient was symptom free at last follow-up, 24 months after surgery

providing data on the rate of locking plate implant failure in patients with pathologic fracture caused by bone metastasis alone. All the previous studies have included patients with primary bone tumours or a mixture of patients with primary bone tumours and bone metastasis. This difference may explain some of the variability in the rate of implant failure. Further, the mean duration follow-up in our study (27.2 months) is far longer than that in previous studies involving locking plates, in which follow-up has ranged from 13.8 to 18.2 months (6-9). Taken together, our findings and those from previous studies, suggest that fixation of pathologic fractures using locking plates is associated with a low rate of implant failure.

We found that use of locking plates in the treatment of pathologic fractures or impending pathologic fractures caused by bone metastasis was associated with a low rate of complications. Indeed only 1 of 10 patients (10%) experienced a complication that was procedure-related. This complication, superficial infection, was successfully treated with debridement and has been described in other studies reporting on the treatment of pathologic fractures with locking plates (6, 8). The authors of a recently published systematic review reported that 49% of patients who underwent fixation of traumatic proximal humerus fractures with locking plates experienced complications (18). Although the low rate of complication in our study is encouraging, the true rate of complication associated with this procedure is undoubtedly higher and requires elucidation in a larger scale study.

Our study shows several limitations that must be acknowledged. First and foremost, and similar to previous studies of this nature (6-8), our cohort comprised a relatively small number of patients. These patients also showed lesions located in different long bones, meaning that the cohort was not homogenous. Moreover, we did not include a group of patients receiving standard plate fixation for comparison. Quite clearly, a larger study with a comparator group is needed to confirm our findings. Such a study would also allow for comparisons to be made with reference to lesion locations, something, again, that was not possible because of the small numbers in our study. Another limitation is the length of follow-up. Although, our length of follow-up exceeded those reported in the previous studies (6-9), longer follow-up is clearly needed to determine the long-term success of locking plates in the treatment of pathologic fractures caused by bone metastasis. A final limitation is the lack of assessment of functional outcome, pain relief, generally speaking, the quality of life and survival. Given that this means of fixation allows for early weight bearing exercise, we are confident that functional outcomes would be satisfactory.

Conclusions

In this preliminary study we have reported that use of locking plates for treatment of pathologic fractures or impending pathologic fractures caused by bone metastasis was associated with a low rate of implant failure and complication. The small number of patients included in our, admittedly, preliminary study preclude us from making any definitive conclusions; however, we suggest that locking plates may be effective for fixing pathological fractures and impending pathological fractures.

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