DCP Fixation and Autogenous Bone Graft to Treat Nonunion of Femoral Shaft Fracture

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Background. Femoral shaft fracture is a relatively common injury of lower limbs, and surgery using close reduction with interlocking nail fixation usually produces good results with infrequent nonunion. However, some patients do develop fracture nonunion and need further surgical intervention to achieve union. The purpose of this report was to present the clinical results of dynamic compression plate (DCP) fixation with autogenous bone graft which was used to treat eight ununited femoral shaft fractures initially managed by intramedullary (IM) interlocking nailing.

Methods. We treated eight cases of ununited femoral shaft fracture with interlocking nail and later with dynamic compression plate fixation and autogenous bone graft supplementation at the China Medical College Hospital during the past 4 years. The clinical results were evaluated and a drilling technique with Kirschner wire (K-wire) for screw insertion was developed and is presented here.

Results. Seven out of eight fractures united without complications. There was one case in which the nail broke after DCP fixation.

Conclusions. Supplemental plate fixation promotes immediate mechanical stability, especially in terms of resisting torsion stress. Also, the cost of the implant and time consumed for this operation are comparable to other treatments of femoral nonunions. In summary, supplemental plate fixation is a practical and promising method with a good prognosis. Furthermore, the K-wire pre-drilled technique facilitates screw insertion and prevents intraoperative complications.

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Key words

dynamic compression plate, femoral shaft fracture, Kirschner wire, nonunion

INTRODUCTION

Femoral shaft fracture is a common long bone fracture seen in young adults who undergo high-energy trauma. With the advance of internal fixation implants and surgical techniques, close reduction and internal fixation with interlocking nail has become a standard method for treating such injury with good results [1-3]. However, a few cases will eventually develop delay-union or non-union after such treatment. In order to treat such complications, many methods have been proposed. Those which produce satisfactory results include: dynamization by removing screws on either side of the nail [4-6]; removing previously inserted nails and replacing them with larger ones to increases stability [7-9]; excising the non-union tissue on the fracture site and packing autogenous bone graft in situ without removing the original implant [10]. Dynamization has been most often used because of its simplicity. It has been shown to improve osteogenic ability by

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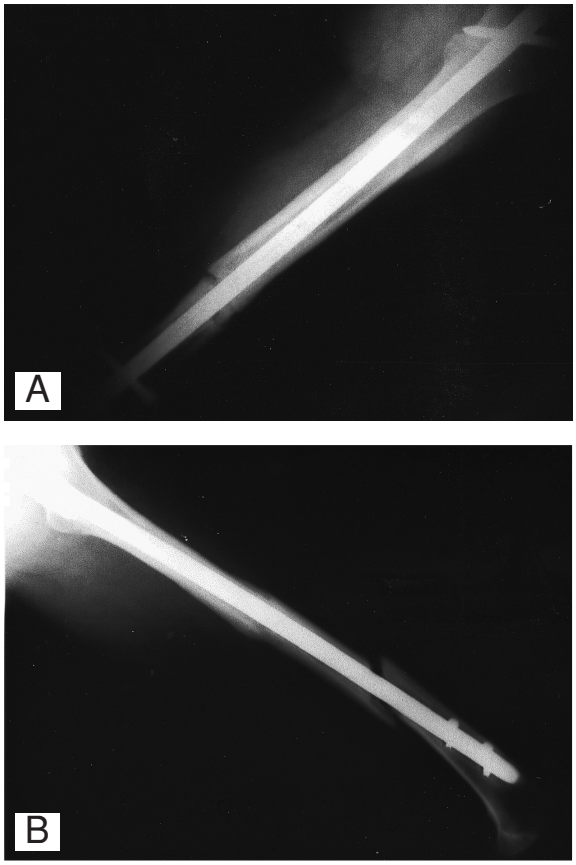

Fig. 1. A: X-ray of right femur of case 1, nonunion was noted 56 months after initial intramedullary nail fixation; B: X-ray of right femur of case 6, nonunion was noted 13 months after initial intramedullary nail fixation.

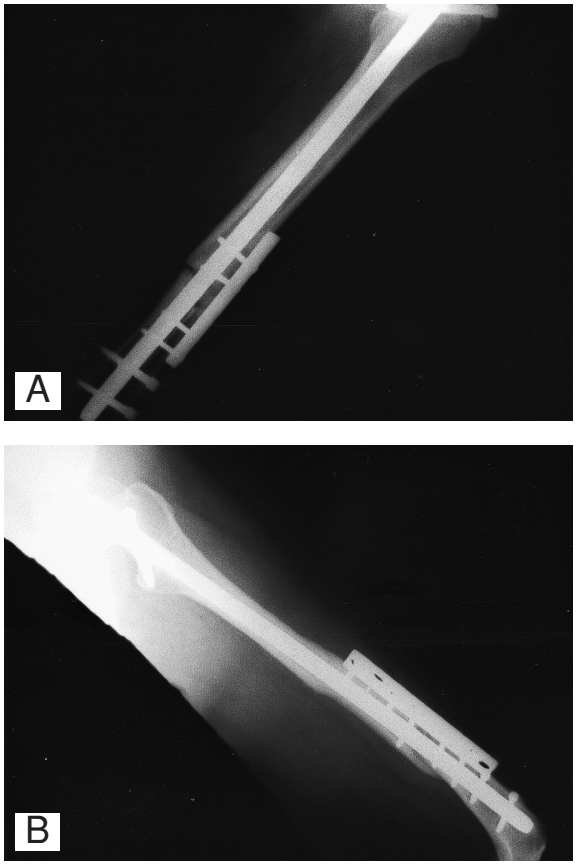

Fig. 2. A: X-ray of right femur of case 1, augmented DCP fixation with ABG was performed; B: X-ray of right femur of case 6, augmented DCP fixation with ABG was performed.

increasing the compressive stress across the fracture sites. However, femur shortening and nail migration often occur and some fractures do not unite. Radiological follow-up is necessary in order to detect such complications early [4-6]. Exchanged reamed intramedullary nails have also been used but with varying success [7-9].

Recently, augmentative plate fixation with the intramedullary nail left in situ with or without autogenous bone graft supplementation has been proposed as an alternative treatment of femoral fracture non-union [11,12]. We treated eight cases and forwarded our experience to others in treating such complications of non-union with DCP fixation and autogenous bone graft supplementation.

MATERIALS AND METHODS

Basic Data Analysis

A total of eight cases were reviewed in this study. Between November 1997 and October 1999, all eight cases had femoral shaft fracture and received open reduction and internal fixation (ORIF) or closed reduction and internal fixation (CRIF) with interlocking nail as the definite or primary management of fracture (Figs. 1A, 1B). Subsequently, because of non-union, all patients received DCP fixation and autogenous bone graft (Figs. 2A, 2B).

There were three females and five males: (age range: 14–68 years, mean: 29.4 years). Of the eight cases, three were open fractures: two type II and one type IIIa fractures according to Gustilo classification [13]. One fracture was located at the proximal third, two were at the distal third and five were at the middle third.

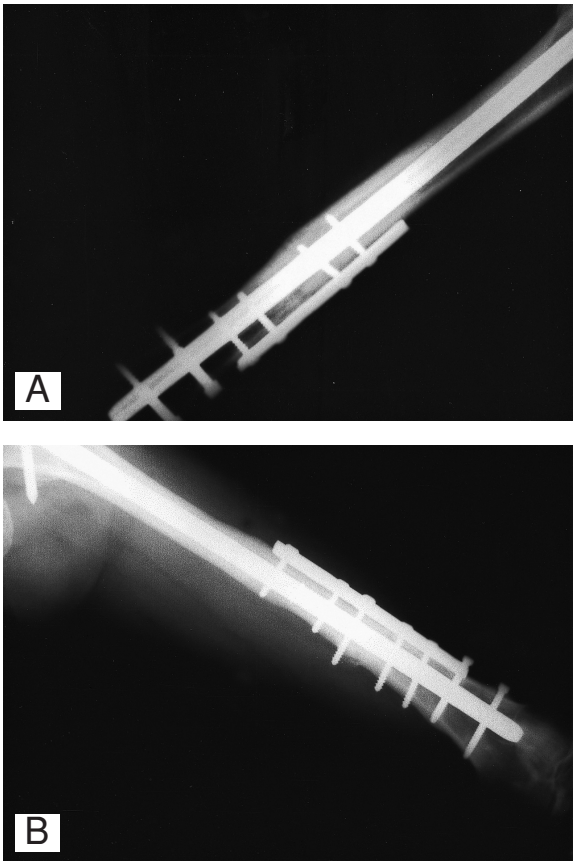

Fig. 3. A: solid union achieved 39 months after DCP application in case 1; B: solid union achieved 18 months after DCP application in case 6.

Initial fixation methods included ORIF with interlocking nail (4 cases) and CRIF with interlocking nail (4 cases). Nonunion was diagnosed between 6 months and 56 months after the initial operation, with a mean duration of 17.6 months.

All eight cases subsequently received DCP fixation with autogenous bone graft supplementation. Case 5 had initially received dynamization but nonunion persisted. Partial weight bearing was initiated for all eight cases after surgery. Detailed data are shown in Table 1.

Operation Procedure and Technique

Each patient was placed in a lateral decubitus position with the involved side up. Through a lateral approach to the thigh, the lateral aspect of femur and the nonunion site were exposed. At the same time, autogenous bone graft was harvested from the ipsilateral ASIS. Fracture site stability was evaluated by rotating the distal fragment of femur, and gross instability was found in all cases. We then decorticated the ends of the fracture fragments and cleaned the fibrotic tissue between the fracture gaps. Autogenous bone graft was then packed around the fracture site and a short broad DCP was applied and fixed on the lateral aspect of femur with four to six cortices on both sides of the fracture site. The previously inserted interlocking nail was left in situ.

While preparing for screw insertion and drilling, we used the K-wire pre-drilled technique instead of the standard drill-bit technique to facilitate screw tract formation. With the inherent elasticity of 2.0-mm-diametered K-wire, the technique made transcortical tunnels very easily and avoided hardware breakage and metal abrasion with the intramedullary nail that frequently occurs with the traditional drill-bit technique. Then 3.0-mm-diametered K-wire was used to enlarge previous tunnels, and then cortical screws were inserted into the tunnels to fix the DCP after tapering.

RESULTS

Seven patients (case 1 to 7) eventually achieved solid and bony union (Figs. 3A, 3B) according to radiological findings, and all were free of clinical symptoms at the latest follow-up.

Mean union time from DCP fixation to solid union was 15 months (range: 4–39 months). Mean time of nonunion from the initial IM nail fixation to DCP fixation for treating nonunion was 17.6 months (range: 6–56 months). Mean follow-up duration from plate fixation to definite solid union was 15.9 months (range: 7–39 months). None of the patients had significant blood loss nor needed post-op blood transfusion. Mean operation time was 97 minutes (range: 60–120 minutes). No complications occurred during the procedure.

Follow-up radiograph showed that the IM nail failed with intact DCP one month after plate fixation in case 8. Removal of the DCP

Table 1. Basic data of eight patients before plate fixation for nonunion

Case No.	Age/Sex	Side	Fracture pattern	Location	Initial surgery	Complications before op
1	51/M	L't	Closed, simple	D/3	ORIF+ILN	Nil
2	21/M	L't	Closed, simple	M/3	ORIF+ILN	Broken screw
3	13/M	R't	Open type II, butterfly fragment	M/3	ORIF+ILN	Nil
4	22/M	L't	Open type IIIa, butterfly fragment	M/3	ORIF+ILN	Nil
5	25/F	R't	Open type II, butterfly fragment	D/3	ORIF+ILN	Nil
6	38/F	R't	Closed, segmental, oblique fracture line	M/3	ORIF+ILN	Nil
7	35/F	R't	Closed, displaced butterfly fragment	P/3	ORIF+ILN	Nil
8	30/M	R't	Closed, simple	M/3	ORIF+ILN	Nil

M = male; F = female; L't = left; R't = right; M/3 = middle third; P/3 = proximal third; D/3 = distal third; ILN = interlocking nail; ORIF = open reduction and internal fixation; CRIF = close reduction and internal fixation.

Table 2. Follow-up data of eight patients after plate fixation

Case No.	Nonunion period (mo)	Type of nonunion	OP time (min)	F/U time (mo)	Time to solid union (mo)	Complications post plate fixation
1	56	Atrophic	100	39	39	Nil
2	13	Atrophic	120	9	9	Nil
3	7	Atrophic	90	15	11	Nil
4	6	Atrophic	100	20	20	Nil
5	9	Atrophic	*	7	4	Nil
6	13	Atrophic	110	19	18	Nil
7	12	Atrophic	60	7	6	Nil
8	25	Hypertrophic	230	14	*	Broken nail

*data not acquired from chart or patient.

and nail and re-fixing with IM nail was performed. Hypertrophic non-union with a radiolucent gap was noted at 8 months follow-up. The other patients experienced no complications during the period from DCP fixation to solid union. The detailed data are shown in Table 2.

DISCUSSION

Some predisposing factors contributing to fracture nonunion include fracture site located near both ends of the femoral shaft, open reduction, and fracture pattern with high energy [14,15]. (i.e., segmental fractures, comminuted fractures, open fractures etc.). All of these factors contributed to nonunion or delayed union.

DCP augmentation has been proven to be a practical method for the management of delayed union and nonunion of femoral shaft fracture after IM nail fixation [11,12]. However, the existing intramedullary nail might hinder the insertion of cortical screws with the routine drill-bit technique. If handled carelessly, the drill-bit may break upon contact with the nail. The broken piece of the tip of the drill-bit then might remain in the bone canal, making DCP fixation more troublesome and complicated. Therefore, we present the K-wire pre-drilled technique to avoid such problems and to make the whole procedure much smoother.

During the operation, rotational instability was noted on fracture site in all patients in spite of previous static intramedullary interlocking nail fixation. Theoretically, interlocking nail can achieve static stability after application. However, it is difficult to obtain genuine mechanical stability because some gaps may exist between the cortex holes and screws if the screw holes do not have close contact with the screws, thus making rigid stability impossible. Fracture instability warranted the application of DCP

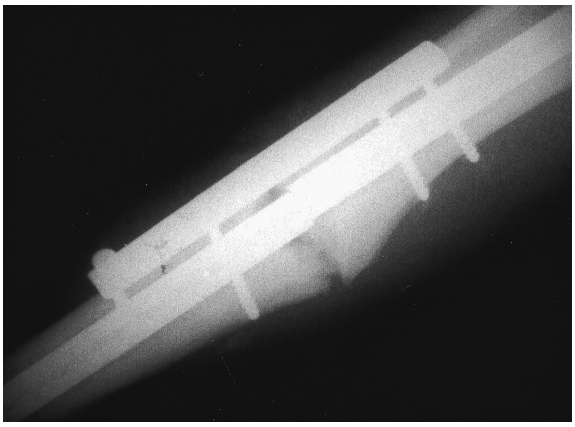

Fig. 4. X-ray of right femur of case 8, broken nail was noted 1 month after DCP application.

fixation because the fracture site would gain immediate and rigid stability after plate application

The IM nail broke in case 8 one month after plate fixation (Fig. 4). This finding was noted on radiographs when he visited our hospital because of sudden onset of thigh pain and swelling while he was jogging. A reasonable explanation for this finding is that the length of the IM nail was longer and had a larger lever arm away from the fracture site than the plate, so it sustained much more bending force as the patient was jogging and bearing weight on it. Another explanation is that the plate did not fix well to the lateral cortex, so the plate was spared the bending force.

We added autogenous bone graft in all the cases to promote the healing of the fracture site because the majority of our cases had dystrophic nonunion on pre-operative radiographs. With hypertrophic nonunion, bone graft may not be necessary because stability of the fracture site should be the first concern when treating nonunion.

The relative long union time in our study as compared to others [9-11] may be due to longer follow-up intervals after surgery. However the majority of our cases with callus formation developed solid union from 1 to 3 months after fixation and bone graft supplementation. Operation time and blood loss are comparable to other methods, such as lateral and endosteal plating with primary iliac crest bone grafting and indirect plating techniques in the treatment of femoral shaft nonunions [16,17].

The criteria of DCP fixation and bone graft to treat nonunion include 1) any type of nonunion of femoral shaft fracture after IM nailing, especially the hypertrophic type, 2) failed dynamization or failed exchanged nailing after nonunion, and 3) nonunion with unstable fracture pattern. The contraindication includes septic nonunion with active infection.

In summary, DCP fixation with autogenous bone graft supplementation and the K-wire pre-drilled technique is a useful alternative to traditional methods for treating nonunion of femoral shaft fractures. The advantages of these procedures include simplicity, a quick operation process, and low cost compared to other methods. Most importantly, it had high union and few complications.

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使用動態壓迫性鋼板及自體骨移植治療股骨幹骨折未癒合

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背景 股骨幹骨折是一種常見的下肢創傷，外科手術使用閉鎖式復位加交錯式骨髓內釘固定通常有不錯的結果且未癒合並不常見,然而仍有一些病人發生骨折未癒合的情形，需要更進一步的治療來達到癒合。本篇報告的目的在評估使用動態壓迫性鋼板固定加上自體骨移植來治療八個使用骨髓內鋼釘固定股骨幹骨折後未癒合之臨床效果。

方法 過去4年內來在本院有八例接受使用動態壓迫性鋼板固定加上自體骨移植來治療股骨幹骨折經骨髓內釘固定後未癒合之病例。我們評估治療的臨床結果，並且提出一種使用K-鋼針鑽孔的修正技術來改善螺絲植入。

結果 八個病例中有七個病例達到密實之癒合且無併發症，一個病例在鋼板固定後發生骨髓內釘斷裂的情形。

結論 加強性的鋼板固定可以提高立即的力學穩定度，特別能抵抗扭轉應力，並且在手術時間及植入固定器費用上和其它治療股骨未癒合的方法相比是相當的。總之，此種方法是可行而有希望的,並有不錯的預後。而且，藉由K-鋼針預鑽孔的技術可以幫助螺絲鎖入，避免術中併發症的發生。（中台灣醫誌 **2002;7:215-21**）

關鍵詞

動態壓迫性鋼板，股骨幹骨折，K-鋼針，未癒合

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