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Original article

Blade-plate fixation for distal femoral fractures: A case-control study

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ABSTRACT

Background: The blade-plate is the earliest of the contemporary internal fixation devices introduced for distal femoral fractures. The recent development of dedicated, fixation devices has considerably limited its use. The objective of this study was to evaluate outcomes after blade-plate fixation and after fixation using other devices.
Hypothesis: Outcomes after blade-plate fixation are similar to those after condylar screw-plate, distal femoral nail, or locking condylar plate fixation.
Material and methods: We reviewed outcomes after 62 patients managed with blade-plate fixation and included in a multicentre retrospective study ($n = 57$) or a multicentre prospective study ($n = 5$) and we compared them to outcomes after fixation using condylar screw-plates ($n = 82$), distal femoral nail ($n = 219$), or locking condylar plates ($n = 301$). The four groups were comparable for age, gender distribution, occupational status, prevalence of skin wounds, patient-related factors, type of accident, and type of fracture. The evaluation relied on the clinical International Knee Society (IKS) score and on radiographs.
Results: No significant differences existed across the four groups for operative time, blood transfusion use, complications, need for bone grafting, non-union rate, or IKS score values. The early surgical revision rate for removal of the fixation material was 4% with the blade-plate and 16% with the other three fixation devices ($P = 0.02$). Post-operative fracture deformity was similar in the four groups with, however, a higher proportion of residual malalignment in the screw-fixation group. The final anatomic axis was $3.3 \pm 1.4^\circ$ with the blade-plate versus $2.3 \pm 3.7^\circ$ with the other three fixation devices. The blade-plate group had few patients with axial malalignment, and the degree of malalignment was limited to 3° of varus and 10° of valgus at the most, compared to 10° and 18° respectively, with the other three fixation devices.
Conclusion: Despite the now extremely limited use and teaching of blade-plate fixation, as well as the undeniable technical challenges raised by the implantation of this device, the blade-plate is a simple, strong, and inexpensive fixation method. It remains reliable for the fixation of distal femoral fractures. The disfavour into which the blade-plate is currently falling is not warranted.
Level of evidence: III, case-control study.

1. Introduction

The use of internal fixation to treat distal femoral fractures became standard practice only in the 1970s, when the surgical indications were broadened to displaced intra-articular fractures, a change that improved the functional outcomes. The optimal means of stabilising a distal femoral fracture was rapidly recognised as involving support from a diaphyseal plate combined with maximal-strength anchoring into the metaphysis and epiphysis. Thus, the 95° angled Müller blade-plate with no guidewire, initially designed for proximal femoral fractures, and the Judet screw-plate became the two preferred fixation options among

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European surgeons. The Strelitzia blade-plate, known as the Maconor device, was introduced in 1975; angles of 90°, 100°, and 110° were available in the Maconor 1 version and, in 1987, a 95° fixed-angle option known as Maconor 2 was added to ensure guide wire positioning parallel to the joint space.

To date, no formal consensus exists about which fixation device is optimal for distal femoral fractures. Nevertheless, the growing popularity of contemporary condylar screw-plates, locking condylar plates and, finally, dedicated retrograde distal femoral nails recently prompted the major companies to stop producing Strelitzia blade-plates. At present, a single company, based in France, continues to produce and distribute the blade-plate to surgeons, particularly those in teaching hospitals, who want continued access to this simple, inexpensive and effective fixation device.

The objective of this study was to determine whether the use of this early fixation device remained reasonable. We compared clinical and radiological outcomes after blade-plate fixation to those after fixation using the three most widely used devices. Our hypothesis was that blade-plate fixation provided similar outcomes to those seen with condylar screw-plates, distal femoral nails, or locking condylar plate.

2. Patients and method

During the 2013 meeting of the French Society of Orthopaedic and Trauma Surgery (SOFCOT), the results of two multicentre studies were reported. One was retrospective and the other prospective, and the patients were recruited at 12 surgical centres.

Inclusion criteria were a distal femoral fracture included in the AO epiphyseal square or a diaphyseal-metaphyseal-epiphyseal distal femoral fracture, namely, a supracondylar fracture, supracondylar/intercondylar fracture, or uni-condylar fracture. Both studies excluded pathological fractures, peri-prosthetic fractures of the knee, fractures in children younger than 15 years and 3 months of age, and epiphyseal slippage fractures in individuals older than 15 years of age. The retrospective study included patients managed between January 2001 and December 2010 and the prospective study patients managed between June 1, 2011, and May 31, 2012 who had a follow-up of at least 1 year. For each patient, an online folder containing information sheets and standard pre-operative and post-operative imaging studies was created. The data in the folders allowed the analysis and validation of the fracture type in the universal Orthopaedic Trauma Association (OTA) classification available online on the OTA site [1]. Clinical outcomes were evaluated using the International Knee Society (IKS) knee and function scores [2].

Of the 899 included patients (716 in the retrospective study and 183 in the prospective study), among patients managed with internal fixation 62 were managed with blade-plates (5 in the prospective study and 57 in the retrospective study), 82 with Chiron- or DCS-type plates or condylar screw-plates, 219 with distal femoral nails, and 301 with locking condylar

Table 1
Models used for the four types of internal fixation.

Blade-plate ($n=62$)	Plate or screw-plate ($n=82$)	Nail ($n=219$)	Locking plate ($n=301$)
LP Strelitzia (Medicalex), $n=40$ LP AO (Zimmer), $n=22$	Chiron screw-plate (Howmedica), $n=55$ DCS screw-plate (Zimmer), $n=23$ Standard plates, $n=4$	T2 Supracondylar Nail (Stryker), $n=128$ Trigen (Smith and Nephew), $n=46$ Other nails, $n=45$	LCP (Synthes), $n=230$ AxSOS and Numelock (Stryker), $n=4$ PDF Locking Plate (Zimmer), $n=15$ Other locking plates, $n=15$

Table 2
Pre-operative data.

Type of internal fixation	Blade-plate ($n=62$)	Plate or screw-plate ($n=82$)	Nail ($n=219$)	Locking plate ($n=301$)
Age (years)				
m	63.1	57.8	64.6	60.7
SD	25.5	23.7	23.1	24.1
Min	15	16	16	15
Max	102	95	101	105
Sex				
F (%)	63	46	64.4	55.1
M (%)	37	54	35.6	44.9
BMI				
m	21.9	22.2	22.1	24.2
SD	8.8	9.2	8.1	7
Status				
Retired (%)	63	47	62	53
Employed (%)	37	53	38	47
Type of accident (%)				
Fall from standing height 61	48	62	55	
Fall from elevated height	10	14	9	6
2-wheel vehicle accident	10	23	4	17
Car accident	14	11	12	14
Motor vehicle-pedestrian accident	5	0	0	3
Sport injury	0	1	0	3
Other	0	3	3	2
AO fracture type (%)				
A	48	33	55	45
B	0	4	2	7
C	52	63	43	48
Compound fracture (%)	23	22	19	15

n: number of patients; m: mean; SD: standard deviation; min: minimum value; max: maximum value.

Table 3
Intra-operative data.

Type of internal fixation	Blade-plate ($n=62$)	Plate or screw-plate ($n=82$)	Nail ($n=219$)	Locking plate ($n=301$)
Surgeon				
Junior (%)	56	29	28	26
Senior (%)	44	71	72	74
Operating time (min)				
m	124	118	100	116
SD	45	40	98	53
Number of RBC units				
m	1.2	1.1	1	1.4
SD	1.9	2	1.6	2.1

n: number of patients; m: mean; SD: standard deviation; min: minutes; RBC: red-blood-cell.

plates. Table 1 lists the fixation device models used in the four groups.

No significant differences were present across the four groups for the following pre-operative data: age, gender distribution, body mass index, occupational status, presence of a skin wound, type of accident, and type of fracture (Table 2).

For the statistical analysis, we used the Chi^2 test, non-parametric Fisher's test, and non-parametric Mann-Whitney test. Values of $P \leq 0.05$ were considered significant.

*SOFCOT 2013 (88th meeting, Paris, France; November 2013); Treatment of supracondylar, intercondylar, and uni-condylar fractures of the distal femur.

3. Results

Table 3 reports the main intraoperative data. The comparisons between the blade-plate group and the other three groups combined produced the following results:

- mean operative time in minutes, 124 ± 45 versus 110 ± 74 ($P=0.049$);
- number of transfused red-blood-cell units, 1.17 ± 1.95 versus 1.23 ± 1.89 ($P=0.8630$);
- proportion of patients operated on by junior surgeons (clinical fellows) versus senior surgeons (with post-fellowship experience), 56% and 44%, respectively, for the blade-plate versus 28% and 72%, respectively, for the other devices ($P=0.00001$), indicating that the blade-plate was used significantly more often by younger surgeons.

3.1. Radiological outcomes

The post-operative data in the overall study population were as follows (Table 4):

- the post-operative deformity results on the antero-posterior and lateral radiographs were similar across the four groups, with however a trend towards greater malalignment in the coronal plane (chiefly in valgus) and sagittal plane (in both recurvatum and flessum) in the group managed with distal femoral nail fixation;
- good restoration of the final anatomic axis overall, although, compared to the other three groups combined, the blade-plate group had a smaller standard deviation ($3.3 \pm 1.4^\circ$ versus $2.3 \pm 3.7^\circ$) (Fig. 1) and few frontal deviations with smaller angle values

Table 4
Radiological outcomes.

Type of internal fixation	Blade-plate ($n=62$)	Plate or screw-plate ($n=82$)	Nail ($n=219$)	Locking plate ($n=301$)
Fracture site deformity on AP view (%)				
Restored axis	74	78	69	79
Valgus at the fracture site	16	11	23	17
Varus at the fracture site	10	11	8	4
If valgus, (°)				
m	3.3	3.3	6.3	6.8
SD	1.7	0.9	4.4	3.4
If varus, (°)				
m	5.6	4.7	5.1	6.1
SD	1.9	2.3	1.9	2.6
Fracture site deformity on lateral view (%)				
Restored axis	73	76	62	79
Recurvatum at the fracture site	14	18	20	15
Flessum at the fracture site	13	6	18	6
If recurvatum, (°)				
m	11.2	7.6	7.4	8.6
SD	5.4	7.6	3.9	5.2
If flessum, (°)				
m	12.8	6.4	8.4	4.9
SD	5.6	5.2	5.9	1.9
Final AP TF angle (°)				
Valgus				
m	3.3	2.1	2.4	2.4
SD	1.4	1.9	3.1	4.4
Varus Max	3	8	11	10
Valgus Max	10	16	16	20

n: number of patients; m: mean; SD: standard deviation; AP: antero-posterior; TF: tibio-femoral.

Fig. 1. Supracondylar/intercondylar fracture type C33: antero-posterior (A) and lateral (B) radiographs. Blade-plate fixation: antero-posterior (C) and lateral (D) views.

(maximal varus and valgus, 3° and 10°, respectively; versus 10° and 18°, respectively).

3.2. Post-operative course

The following results were obtained by comparing the blade-plate group to the three other groups combined (Table 5):

- no significant differences for the absence of early complications (90% versus 83%; $P = 0.64$), infection rate (2% versus 5%; $P = 0.75$), or disassembly rate (2% versus 5%; $P = 0.54$);
- significantly lower rate of early revision surgery for fixation material exchange due to disassembly and/or non-union in the blade-plate group than in the other three groups combined (4% versus 16%, respectively; $P = 0.02$) (Fig. 2);
- similar rates of re-operation for secondary bone grafting (10% versus 12%, respectively; $P = 0.78$);
- similar final union rates (87% versus 84%; $P = 0.75$);
- similar rates of delayed fixation material removal after fracture healing (17% versus 17%; $P = 0.88$);
- and similar IKS scores (124 versus 127, respectively; $P = 0.89$).

4. Discussion

This study showed no differences between blade-plate fixation and other fixation methods regarding the complications, need for bone grafting, healing rate, final functional score, disassembly rate, or need for early revision surgery. The tibio-femoral axis was usually acceptable, with few cases of mal-union. These results were

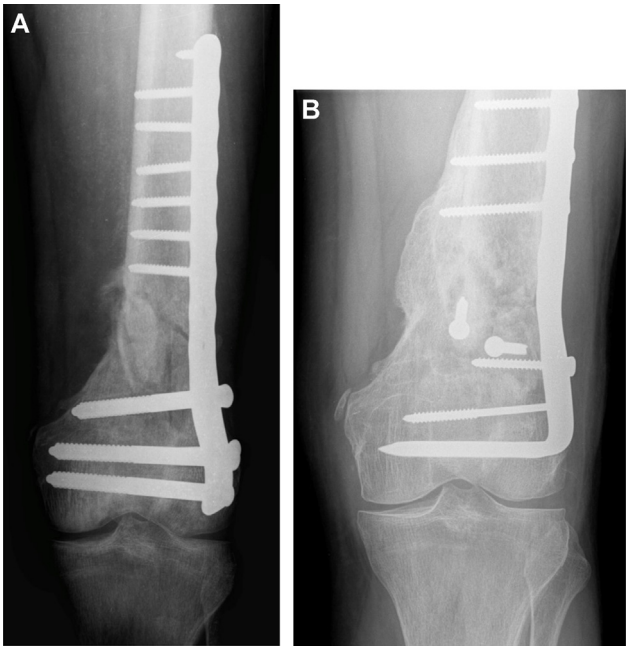

Fig. 2. Disassembly 2 months after Chiron condylar screw-plate fixation of a supracondylar type A12 fracture (A). Healing was achieved after revision surgery with blade-plate fixation (B).

Table 5
Post-operative course.

Type of internal fixation	Blade-plate ($n=62$)	Plate or screw-plate ($n=82$)	Nail ($n=219$)	Locking plate ($n=301$)
Complications (%)				
None	90	87	81	83
Infection	2	4	6	5
Deep vein thrombosis	2	0	4	3
Disassembly	2	7	4	5
Other (nerve injury, compartment syndrome, skin abnormality...)	4	2	5	4
Early material removal for revision	4	28	12	16
Secondary bone grafting (%)	10	22	10	10
Final healing (%)				
Healed	87	87	81	84
Non-union	13	13	19	16
Delayed material removal (%)	17	32	16	15
IKS score				
m	124.5	150.5	128.5	127
SD	55	35.9	48	50.8
IKS function score				
m	52.3	75.8	58.4	56.2
SD	45.8	29.7	38.6	41.5
IKS knee score				
m	72.1	74.7	70.1	70.8
SD	14	13.6	16.8	15.9

n: number of patients; m: mean; SD: standard deviation.

obtained despite the significantly younger age of the surgeons in the blade-plate group.

The main strengths of this study are the large sample size, with 899 patients, and the comparison of the blade-plate to various other devices, namely, condylar screw-plate, dedicated distal femoral nail, and locking condylar plate. The four groups were comparable for age, gender distribution, body mass index, occupational status, fracture mechanism, fracture type, and skin wounds. We are not aware of any other published studies comparing these four internal fixation techniques.

The limitations of the study consist of the multicentre patient recruitment; retrospective data collection in most of the patients; variability across surgical schools of thought and surgical techniques; and variability in the brands and models of fixation devices used.

Blade-plate fixation has been compared to condylar screw-plate fixation in earlier studies. The only comparative biomechanical study used synthetic femurs that were cut to simulate supracondylar fractures type A3 with a 1-cm gap [3]. The results were better with the DCS condylar screw-plate, which was associated with significantly greater values for stiffness in axial compression and maximal load compared to the blade-plate, although the fatigue characteristics were not significantly different between the two devices.

A clinical retrospective study reported in 2010 compared the DCS condylar screw-plate ($n=54$) to the blade-plate ($n=24$) [4]. All patients had supracondylar-intercondylar fractures (type C). The condylar screw-plate was associated with better outcomes in terms of the rates of non-union (5% versus 25%), varus deformity (4% versus 25%), and global Schatzker score (96% versus 71% of good or excellent results) [5]. The authors conclude that the DCS device is easier to implant than the blade-plate, which raises major technical challenges, as the two separate pieces of the DCS allow greater freedom in the manoeuvres used to reduce the fracture.

Several studies compare the blade-plate to locking condylar plates. In addition to reports of complications with locking condylar plates, such as non-union and plate fracture [6–8], several recent studies challenge the belief that locking condylar plates have mechanical or clinical advantages over blade-plates. A study of fresh-frozen cadaveric femurs reported in 2007 involved simulating supracondylar fractures type A3 [9]. The locking screw-plate exhibited slightly greater mechanical strength compared to the blade-plate, with small differences for axial loading and maximum load to failure. Another biomechanical study, reported in 1997 [10], used embalmed femurs and showed greater resistance to axial loading with the condylar screw-plate than with the blade-plate. In contrast, another comparative biomechanical study of cadaveric femurs, reported in 2006, showed no advantages in terms of axial or torsional stability with the condylar screw-plate compared to the blade-plate in femurs with high bone mineral density [11]. A clinical comparison of 32 blade-plate fixations and 39 Locking Condylar Plate (LCP, Synthes) fixations, published in 2012,showed higher rates in the LCP group of non-union (16% versus 3.4%; $P=0.11$); complications (35% versus 10%, $P=0.001$); and revision surgery (43% versus 6.9%, $P=0.0008$), particularly for removal of protruding material [12]. These findings corroborate the results of our study.

Finally, the blade-plate has been compared to retrograde distal femoral nails. Closed nailing preserves the haematoma at the fracture site, thereby theoretically ensuring better healing with a decreased need for bone grafting, although this possibility has not been confirmed in prospective randomised trials. Biomechanical studies showed better results with the blade-plate than with nailing in terms of resistance to axial and torsional loading [10,13,14].

The only clinical comparative prospective randomised trial compared blade-plate fixation ($n=11$) to retrograde nailing ($n=12$) [15]. The results are in favour of the blade-plate, with no cases of revision surgery compared to 25% of cases in the distal femoral nail group. The operative time was similar in the two groups, a fact pointed out by the authors given the challenges raised by determining the length, alignment, and anatomic joint-surface reduction during distal femoral nail fixation.

Definitive conclusions are not obvious from the small clinical case-series published to date or from the sometimes conflicting results of the available biomechanical studies. In practice, surgeons should be aware of both the advantages and the disadvantages of blade-plate fixation.

The blade-plate is simple, perhaps even rudimentary, as it consists of a single, very strong, piece that cannot be disassembled and

provides considerable fixation strength. Use of the blade-plate is easy, reliable, and rational. Many teams present at the SOFCOT symposium consider the blade-plate to be a rescue option in the event of repeated revision surgery. Finally, the blade-plate is inexpensive, with a 5-fold cost decrease compared to the locking condylar plate [12].

In conclusion, although the dissemination and therefore the teaching of blade-plate fixation have become severely limited, our results do not support discarding the blade-plate as a fixation option for distal femoral fractures. Even when performed by younger surgeons, blade-plate fixation performs as well on all outcomes as do the other fixation devices. Many surgical teams keep blade-plates available for use in rescue surgery. The blade-plate deserves to remain among the valid treatments of distal femoral fractures. The lower cost of the blade-plate compared to other devices, which are associated with undeniable learning curves yet have not been proven to provide better functional or anatomic outcomes, is a major additional argument for continuing and even promoting the use of blade-plate fixation.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article, except for M. Ehlinger, who is an educational consultant for Depuy-Synthes.

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