THE DYNAMIC AXIAL FIXATOR IN FRACTURES OF THE TIBIA AND FEMUR A RETROSPECTIVE STUDY IN 98 PATIENTS

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In a retrospective study involving 98 patients the results achieved with the dynamic axial fixator (Orthofix®) in closed or open fractures of the tibia or femur treated in two district hospitals in the southwest of England during the period 1986-1988 were evaluated. Fifteen patients were vacationers and, as a result, were lost to followup. The operation and subsequent management was performed by more than 15 different members of the staff, of different levels of seniority and experience. The present survey in this group of surgeons has demonstrated that the dynamic axial fixator is a reliable means of treating open fractures of the tibia following an initial good reduction. It does, however, highlight the importance of the strict adherence to simple guidelines for application, pin care and dynamization if best results are to be obtained.

Keywords : tibia ; femur ; fractures ; external fixator ; reduction ; dynamization.
Mots-clés : fractures ; tibia ; fémur ; fixateur externe ; réduction ; dynamisation.

RÉSUMÉ

B. ZACHEE, P. ROOSEN et A. G. Mc AECHERN. L'emploi du fixateur externe type Orthofix® dans le traitement des fractures ouvertes et fermées du tibia et du fémur ; une étude de 98 patients.

Les résultats du traitement des fractures du tibia et du fémur par fixateur externe type Orthofix® entre 1986 et 1988 ont été étudiés dans deux hôpitaux régionaux du Sud-Ouest de l'Angleterre.
Il s'agit de 98 patients, dont 15 vacanciers furent perdus de vue.
Les interventions et le suivi furent réalisés par plus de 15 membres du service d'ancienneté et d'expérience différentes.
Cette étude a démontré que l'Orthofix® est un fixateur fiable pour le traitement des fractures ouvertes du tibia à condition que la réduction initiale soit bonne.
L'étude montre aussi l'importance d'une ligne de conduite stricte pour l'application du fixateur, les soins aux broches et le délai de dynamisation.

SAMENVATTING

B. ZACHEE, P. ROOSEN en A. G. Mc AECHERN. De dynamische axiale fixator voor open en gesloten tibia- en femurfracturen ; een retrospectieve studie van 98 patiënten.

In een retrospectieve studie van 98 patiënten werden de resultaten van tibia- en femurfracturen, behandeld met de Orthofix® fixator, geëvalueerd. De studieperiode loopt van 1986 tot 1988. Vijftien patiënten waren vakantiegangers en gingen bijgevolg verloren voor naonderzoek. De operaties en nazorgen werden verricht door meer dan 15 stafleden met een verschillende ervaring.
Deze studie heeft aangetoond dat, mits een goede initiële reductie, de Orthofix® een betrouwbare behandeling is voor open tibiafracturen. De studie benadrukt eveneens dat een goed resultaat enkel kan verkregen worden mits het navolgen van de raadgevingen i.v.m. het aanbrengen van de fixator, pinverzorging en dynamisatieperiode.

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INTRODUCTION

During the last two decades, important developments in the technique of external fixation have made this treatment modality much more reliable than it was previously, particularly in relation to the management of fractures of the lower limbs. On the basis of biomechanical and clinical studies, devices have been designed which allow fracture compression or distraction and accurate alignment of fragments, while permitting both stability and micromovement at the fracture site, with the aim of creating the ideal physiological condition at each stage of the fracture-healing process.

De Bastiani *et al.* (5, 6) described their results in a series of fractures treated with a new monolateral (uniplanar) device with tapered half-pins. Biomechanical studies (2) demonstrated that the Orthofix Dynamic Axial Fixator (DAF) has higher anterioposterior and lateral bending stiffness, equivalent torsional stiffness and lower axial stiffness than the Hoffmann-Vidal quadrilateral frame with full pins. The factors responsible for its mechanical performance are the rigid body device, the strong ball joints between body and screw clamps and the larger diameter of the pins (6 mm at the bone cortex nearest to the device).

In addition, the fixator body incorporates a telescopic device which allows rapid conversion from a static to a dynamic mode by the turn of a single screw. This permits dynamization (intermittent loading of the fracture site) on weightbearing at an appropriate state in the healing cycle.

In the present paper the clinical use of the DAF in the treatment of diaphyseal fractures of the tibia and femur has been evaluated retrospectively.

MATERIAL AND METHODS

During the period 1986-1988, 98 patients with 101 fractures of the tibia or femur were treated in two district general hospitals in the southwest of England. Fifteen patients, mostly vacationers, were lost to followup, leaving 83 patients with 85 fractures available for study. The data presented were derived from the case notes and xrays of this group of patients. There were 71 men and 12 women in the group studied. The average age was 42 years (range 14-88 years). Fracture severity was graded according to the scale detailed in table I.

Table I. — System for classification of fracture severity

Grade 0	Closed fracture
Grade 1	Puncture wound (inside to outside) only
Grade 2	Wound (outside to inside) with some tissue damage
Grade 3A	Wound (outside to inside) with extensive soft tissue damage but no vascular damage
Grade 3B	Wound (outside to inside) with extensive soft tissue damage and vascular damage

Initial operative treatment was undertaken by both senior and junior medical staff. Open fractures were treated with debridement, irrigation, delayed primary closure and antibiotic therapy for at least 36 hours (4). Follow-up care was provided by more than 15 doctors with varying levels of familiarity and experience with the device.

While most devices were dynamized at a time when some callus formation was already evident, some were not dynamized at all because the surgeons involved were unaware of this requirement. This omission provided us with an opportunity to investigate the clinical importance of this property of the DAF.

Patients were instructed in pin-site care with Betadine® or Hibitane® solution during their stay in the hospital, Physiotherapy and mobilization of adjacent joints were initiated as soon as possible after operation.

RESULTS

The number of compound fractures and their severity is shown in table II.

Consolidation (healing) time was defined as the time to full unsupported weightbearing. On this basis, the mean healing time for tibial fractures was 28.5 weeks (range 10-72 weeks). Ten of the original group of 60 tibial fractures were excluded from this analysis because of major complicating factors, i.e. osteomyelitis (2 cases) ; application of

the DAF more than 4 weeks after injury (6 cases) ; vascular lesions (2 cases).

Table III shows average healing time of tibial fractures in relation to fracture severity. No statistical variance could be established between the groups represented.

In the group of femoral fractures, 4 were excluded from the analysis, one for a vascular lesion and 3 because the DAF was applied more than 4 weeks after injury. The average healing time for the remaining 21 femoral fractures was 19.3 weeks (range 9-36 weeks). Table IV shows average healing time of femoral fractures in relation to fracture severity.

In the tibial group there were 16 transverse fractures, 4 spiral fractures, 10 oblique proximal or distal fractures, 3 segmental and 17 comminuted. Depending upon the stability of the fracture, dynamization was commenced at varying times ranging from 2-12 weeks after fixator application ; in 2 cases dynamization was begun immediately after the fixator was applied and in 7 cases dynamization was not carried out at all. The relationship between healing time and time of commencement of dynamization following application of the device for the 50 tibial fractures included in the analysis is shown in table V. Statistical variance could be found with the SAS system between the group dynamized before 4 weeks and after 9 weeks (Duncan comparison T : 1290).

Of the 21 femoral fractures included in the analysis, 11 were transverse or oblique, 4 were spiral and 6 comminuted. Fifteen were dynamized and 6 were not.

The relationship between healing time and time of commencement of dynamization following application of the device in the group of femoral fractures is shown in table VI.

Remanipulation to correct loss of alignment after application of the fixatore was necessary in 16 of the 60 tibial fractures (26.6%). Eleven patients (18.3%) needed this on one occasion, while 5 (8%) needed it on two or more occasions.

For the purposes of this review, malalignment was defined as more than 10° of angulation in any plane, and shortening as more than 1-cm loss in

Table II. — Classifiction of fracture severity

Grade	Tibia		Femur	
	N	%	N	%
0	10	16.6	19	76
1	16	26.7	1	4
2	22	36.7	2	8
3A	10	16.6	2	8
3B	2	3.4	1	4
Total	60	100	25	100

Table III. — Tibial fractures : healing time and fracture severity

Grade	No of fractures	Average healing time
0	10	28.2 weeks
1	13	27.0 weeks
2	20	26.3 weeks
3A	7	37.5 weeks

Table IV. — Femoral fractures : healing time and fracture severity

Grade	No of fractures	Average healing time
0	17	18.3 weeks
1	1	36.0 weeks
2	1	24.0 weeks
3A	2	18.5 weeks

Table V. — Tibial fractures : relationship between dynamization time and healing time

Time dynamization commenced	No fractures	Average healing time
< 4 weeks	14	24 weeks
5-8 weeks	15	27 weeks
> 9 weeks	14	36.5 weeks
Not dynamized	7	29.3 weeks

Table VI. — Femoral fractures : relationship between dynamization time and healing time

Time dynamization commenced	No fractures	Average healing time
< 4 weeks	3	20 weeks
5-8 weeks	8	18.5 weeks
> 9 weeks	4	16 weeks
Not dynamized	6	23.8 weeks

segment length (11). Using these criteria, malalignment occurred in 11.6% and shortening in 6.6% of the tibial fractures.

Of the 25 femoral fractures, 11 (44%) required remanipulation for loss of reduction. In 7 (28%) this was necessarily only once, and in 5 (20%) on two or more occasions. Malalignment occurred in 20% and shortening in 8%. In the femoral group, remanipulation was most frequently required for varus angulation.

Thirteen out of 60 tibial fractures (22%) underwent surgical reintervention for delayed union or the fear that delayed union might develop. Average time of reintervention was 15.5 weeks after initial injury. In 2 patients fibulotomy alone was performed ; in 3, fibulotomy plus phemister grafts (3) ; in 7, grafting alone ; and in one, a tibial osteotomy plus grafting. Union was achieved in all of these cases after a mean time of 24 weeks from reoperation.

It was of interest to note that while 7 of 50 open tibial fractures required reintervention (14%), 6 of the 10 closed tibial fractures (60%) also did. The figures are shown in table VII.

Of the 25 femoral fractures, in 2 the fixator was removed and replaced with an intramedullary nail, while one fracture required bone grafting. The average time of reoperation was 6.6 weeks after initial injury. No cases of nonunion occurred (tabl. VIII). A review of pin-tract problems indicated that 27 out of 60 patients in the tibial fracture group (45%) had one or more infected pin sites, while in the femoral fracture group 13 out of 25 patients demonstrated infection of a pin site. *Staphylococcus aureus* and *Staph. epidermidis* were the main pathogens isolated. Only one infected tract developed a sequestrum which required treatment by pin removal and sequestrectomy. The method of classification of pin-track infection employed in the present review is shown in table IX, and the number of occurrences in each grade, in table X.

The DAF was not kept in place until union was achieved in every case. In 35 out of 50 tibial fractures (58.3%) the DAF was retained in situ until consolidation had occurred. The reasons for premature removal of the DAF were : pin problems (9 cases), delayed union (6 cases), refracture (1 case), loose fixator body (1 case), poor application technique (1 case) and no reason recorded (7 cases). Where early removal occurred, most cases received a Sarmiento cast or a gaiter. The average time to consolidation of those tibias, where the DAF remained in situ until healing occurred was 21.7 weeks, compared to 28.5 weeks in those tibias where premature removal of the fixator occurred.

Table VII. — Reoperation following tibial fracture ; relationship to severity

Grade	No of tibial fractures	Reoperation
0	10	6
1	16	2
2	22	3
3A, B	12	2
Total	60	13

Table VIII. — Reoperation following femoral fracture ; relationship to severity

Grade	No of femoral fractures	Reoperation
0	19	0
1	1	1
2	2	0
3A, B	3	2

Table IX. — Classification of pin-tract infections

Grade 1	Resolved with local treatment alone
Grade 2	Resolved with antibiotic therapy
Grade 3	Resolved with pin removal and antibiotics
Grade 4	Sequestrum

Table X. — Pin-tract infection according to grade

Grade	Tibia	Femur
1	8	1
2	12	10
3	7	1
4	0	1

Twenty-one femurs (84%) achieved union with the DAF in situ. Reasons for removal of the fixator in this group of fractures were : pin problems (1 case), varus deformity (1 case), delayed union (1 case) and poor application technique (1 case). Treatment following removal was a K-nail in 2 cases, internal fixation with a plate (1 case) and a plaster cast (1 case).

DISCUSSION

Perhaps the most salient point to emerge from the present survey is the fact that no standard treatment program was followed in reating tibial and femoral fractures with the Dynamic Axial Fixator. As a result of this, in a proportion of the cases studied the guidelines and instructions set out in the seminal papers by De Bastiani and his group (5, 6, 10) were not followed. This contrasts with the practices of other workers (5, 6, 9). As a consequence of this nonuniform use of the apparatus any conclusions drawn from the survey must necessarily be guarded. Most of the femoral fractures in the series were closed, and the healing times do not reflect the end results. In this group of fractures 45.8% required remanipulation due to loss of reduction, and 20% healed with malalignment, mainly varus deformity. The present survey suggests therefore, that closed femoral fractures might better be treated by alternative means (8, 11, 12). In femoral fractures, use of the external fixator should ideally be reserved for such specific indications as compound fractures, burns, polytrauma and head injury, where the operating time needs to be as short as possible (1).

For compound tibial fractures, the present survey confirms the good results previously reported. For closed tibial fractures (10 patients), the results were less satisfactory (average healing time 28.2 weeks). It is noteworthy that 6 out of 10 closed tibial fractures required reoperation for delayed union or the prospect that delayed union might occur. A review of these fractures revealed that in each case initial reduction of the fracture was poor, or dynamization was instituted at a late stage due to a prolonged period of bedrest. Both situations are examples of inappropriate use of the DAF. The compression distraction device should be used for compression in patients with a prolonged period of bedrest. As far as dynamization is concerned, the results of our survey demonstrate the correlation between time of commencement of dynamization and time of fracture consolidation in tibial fractures. Early dynamization (0-4 weeks) produced the best results, and the data suggests that it becomes progressively less useful when initiated more than 4 weeks from the date of injury.

There was no correlation in the group of femoral fractures reviewed, between time of commencement of dynamization and time of fracture consolidation, and this may in part be explained by the smaller numbers involved.

Where malunion occurred in conjunction with either tibial or femoral fractures, our review indicated that in most instances these fractures had been treated by individuals with little or no experience in the use of the device, and that many of the fractures demonstrated a poor initial reduction.

We chose to record the number of patients in whom pintract infection occurred rather than the number of infected pins, since it is the patient who experiences the inconvenience of pin-tract infection. On this basis the infection rate was quite acceptable, and the incidence of grade 3 and 4 infections was low.

The DAF was not retained in place until full consolidation had occurred in 41.7% of the tibial fractures and 16% of femoral fractures. Early removal was usually carried out in situations of delayed union or continuing pin-tract infection. Removal of the fixator in delayed union is again an example of inappropriate use of the device, since under such circumstances healing can usually be achieved by exerting compression at the fracture site using the compression distraction device.

CONCLUSION

Our current survey demonstrates that the DAF is a reliable external fixation device which is less demanding in its application than other available

systems. While the indications for its use in femoral fractures should be carefully observed, it is a very good fixator for compound tibial fractures. Application is straightforward and can be accomplished rapidly. Trauma to soft tissue is minimal, there is no interference with the fracture hematoma and adjustment of reduction subsequent to initial application is readily accomplished. This review does, however, highlight the need for basic simple instruction in the application technique to be provided at the outset for anyone proposing to use the device and the need to follow with care the recommendations and guidelines provided for patient aftercare and rehabilitation.

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