ASPECTS OF CURRENT MANAGEMENT

External fixation devices in the treatment of fractures of the tibial plafond

A SYSTEMATIC REVIEW OF THE LITERATURE

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We have compared the outcomes of the use of external fixation devices for spanning or sparing the ankle joint in the treatment of fractures of the tibial plafond, focusing on the complications and the rates of healing. We have devised a scoring system for the quality of reporting of clinical outcomes, to determine the reliability of the results.

We conducted a search of publications in English between 1990 and 2006 using the Pubmed search engine. The key words used were pilon, pylon, plafond fractures, external fixation. A total of 15 articles, which included 465 fractures, were eligible for final evaluation.

There were no statistically significant differences between spanning and sparing fixation systems regarding the rates of infection, nonunion, and the time to union. Patients treated with spanning frames had significantly greater incidence of malunion compared with patients treated with sparing frames. In both groups, the outcome reporting score was very low; 60% of reports involving infection, nonunion or malunion scored 0 points.

Fractures of the tibial plafond occur mainly as a result of high-energy trauma and represent approximately 1% of fractures of the lower limb.1 The standard treatment has been by open reduction and internal fixation of the fibula and anatomical restoration of the articular surface of the tibia, followed by plate and screw fixation of the medial side based on the AO principles of anatomic reduction of fracture, stable internal fixation preservation of blood supply and early mobilisation. This method gives good results in fractures caused by low-energy trauma.2-4 However, in injuries resulting from high-energy trauma with severe soft-tissue damage and a variable degree of metaphyseal comminution, the introduction of plates and screws through extensive exposures is associated with a high rate of severe complications.5-7

As an alternative, external fixation may be employed in order to reduce the incidence of complications. Two main systems have been developed and can be used in pilon fractures. The ankle spanning system8-11 comprises a unilateral frame anchored at the medial border of the shaft of the tibia and at the calcaneum and neck of the talus with pins, creating a bridge over the ankle joint. The ankle sparing system1,12 is a hybrid of the unilateral frame and the Ilizarov system,13 and consists of a complete ring applied distally in the metaphyseal region with two or three wires. The ring is connected to the frame, and the system is anchored at the diaphysis with two or three pins.1,8-11

These two systems are usually combined with limited internal fixation to augment their rigidity and facilitate restoration of the articular surface. There is little information in the literature as to which device is more appropriate for treating pilon fractures.10 However, the use of hybrid frames and the insertion of wires in association with a compromised soft-tissue envelope, bone fragmentation and joint comminution may influence the rate of infection, which has been reported to be as high as 12%.12

When evaluating the clinical and functional outcomes reported in the ‘Results’ section of comprehensive studies, a single study of level I evidence14 is usually considered insufficient15 to provide a definitive answer to clinical questions. Level I evidence (good quality randomised controlled trials) fulfils the following criteria: concealment; blind or independent assessment for important outcomes; follow-up rate of 85%; adequate sample size. However, multiple studies can lead to confusion because of the variation in both the method and in the presentation of results. Functional outcomes, including physical, social and mental well-being, are presented in a variety of ways, often by questionnaires, while clinical outcomes, such as infection, time to...
union and the range of movement, are expressed only in numerical terms, making the evaluation of data difficult or impractical. A clinical outcome is not just a number. It is affected by the type of fracture, the extent of soft-tissue compromise, the type of reduction and fixation, and the individual characteristics of the fracture and of the patient. Thus, a general report or a statement in the results that “one infection was observed” is of far less value than one which reads, for example, “one infection was observed in a closed fracture with compromise of the soft tissue, treated with closed reduction and external fixation”. The latter has superior quality and contributes much more to summarisation of the data in systematic reviews.

The aim of this systematic review was to compare the efficacy of external fixation devices for sparing or spanning the ankle in the treatment of plafond fractures of the tibia, using a specific methodological procedure.

Materials and Methods

We conducted an internet-based search for English language articles in the medical literature published between 1990 and December 2006, using the Pubmed search engine, with the following key words: pilon, pylon, plafond fractures, external fixation.

All potentially relevant articles were retrieved and assessed for eligibility using the following predetermined selection criteria:

1) The intervention was an external fixation system sparing or spanning the ankle joint, applied as the definitive surgical treatment in patients who had suffered a plafond fracture;
2) The study did not deal with patients suffering from malignancy, paraplegia or nonunion;
3) The study was not an isolated case report;
4) At least 20 patients were included, either in the study or in the subgroup of interest in comparative studies;
5) The quality of the studies, using the previously published scoring system of Papadokostakis et al, should be at least 5 points. The scoring system was developed on the basis of the assessment of the criteria as follows: Were the inclusion/exclusion criteria defined? Was the number of withdrawals or drops-out known? Was the follow-up pre-specified? Were the outcomes of interest clearly described? Did the study include pertinent characteristics, such as the type of fracture, the type of reduction, the use of antibiotic prophylaxis, and the type of surgical approach, which might affect the outcome of interest?

A positive answer to each of these questions scored 2 points, a positive answer without all of the required information scored 1 point and no information at all scored 0 points. Two independent assessors reviewed the studies. Any disagreements were resolved by a consensus.

Quality of outcome reportings. Using standard criteria to evaluate the quality of the studies does not mean that the reported outcomes are of the same degree of quality. In many studies, the outcomes of interest were expressed briefly, without any reference to the individual characteristics which might affect the process of healing or the frequency and severity of complications. When a clinical outcome was reported in the results, we evaluated this report in terms of the type of fracture, the grade of an open fracture, the grade of a closed fracture, the type of reduction and the type of fixation.

Based on these criteria, a clinical outcome should ideally be reported as in the following example: “Osteomyelitis was observed in a patient who had sustained a type II (Rüedi and Allgöwer classification) grade I open fracture. The patient was treated with hybrid external fixation combined with limited open reduction and lag screw internal fixation”.

The quality of outcome reporting consisted of four components: 1) type of fracture, 2) grade of an open or closed fracture; 3) type of reduction; 4) type of fixation. The presence of each of these components scored 1 point, giving a maximum score of 4. In the presence of two or more similar complications, such as two infections, the score was expressed as the mean of the scores of the individual complications.

Statistical analysis. The agreement between the two assessors was analysed using the Bland-Altman method, as well as with linear regression and correlation methods. Categorical variables were compared between the two groups with the chi-squared or Fisher’s exact test, as appropriate. The weighted means of continuous parameters of interest were compared between the two groups using a two-tailed independent samples t-test, with a p-value < 0.05 considered to be significant.

Results

Demographic characteristics. A total of 15 articles describing 459 patients with 465 fractures were eligible for evaluation. The mean age of the patients was 40 years (15 to 83) and 68% (187 of 276) were men. The mechanism of injury was high-energy trauma in 90% (260 of 290), and 24-26% were men. The mechanism of injury was high-energy trauma in 90% (260 of 290), and 24-26% were men. The condition of the soft tissue in closed fractures was classified according to the criteria of Tcherne and Rojczyk, but only four authors used this. Seven articles were eligible for evaluation of the role and efficacy of external fixation spanning the ankle joint (group A, 179 fractures; 38.4%). In four frame a was used articulating at the level of the joint. External fixation sparing the ankle joint (group B, 286 fractures; 61.5%) was evaluated from eight eligible articles. Table I shows the demographic characteristics of the two groups. There were no statistically significant differences between the groups regarding age and the number of open fractures. Group A had significantly...
more type C fractures than group B (Fisher’s exact test, p < 0.001). The quality of the studies did not differ significantly between the groups. No significant correlation was observed between the year of the study and the quality (Table II).

**Infection.** Infection was classified as minor, which included pin track and superficial wound infection, or major, with deep wound infection, osteomyelitis and septic arthritis. A total of 21 minor infections were seen in group A (11.7%) and 106 in group B (37%). This difference was statistically significant (Fisher’s exact test, p = 0.001). The majority of minor infections occurred in relation to the pin tracks (121 of 127, 96%). Major infections were observed in seven patients (3.9%) in group A and in eight (2.7%) in group B (Fisher’s exact test, p = 0.1). One case of septic arthritis was noted in group A and two in group B (Fisher’s exact test, p = 0.1). The numbers of type C and open fractures. The mean time to union was extracted from 11 of 15 studies, describing 310 fractures.

**Time to union.** Information about the time to union was extracted from 11 of 15 studies, describing 310 fractures. Group A contained 138 fractures, including 130 type C and 52 open, while group B included 131 type C and 42 open fractures. There was no statistically significant difference between the groups regarding the type of fracture, the type of reduction and fixation or which type of frame was used. The mean time to union was 4.3 months (group A, 2 to 6; group B, 2.7 to 8.9) in both groups.

**Nonunion and malunion.** Details of nonunion were extracted from 12 studies including 361 fractures. Nine of 131 nonunions were reported in group A (6.8%) and 12 of 230 in group B (5.2%). There was no statistically significant difference between the groups (Table IV). Malunion was evaluated from 12 studies with 353 fractures. Group A (179 fractures) had a statistically significantly greater number of malunions compared with group B (174 fractures) (24 (13.4%) vs 10 (5.7%)) (Fisher’s exact test, p < 0.04). The data were not sufficient to determine any relationship between factors which might influence the process of healing and malunion or nonunion (Table V).

**Range of movement.** Clinical evaluation of dorsiflexion and plantar flexion was possible in six studies including 165 fractures (Table VI). There was no statistically significant difference between patients treated with hybrid frames and those managed with articulated frames. However, the degree of dorsiflexion, but those with hybrid frames had a significantly greater degree of plantar flexion (36.3˚ (14˚ to 60˚)), compared with patients with hybrid frames treated with articulated frames (27.2˚ (10˚ to 42˚)) (two-tailed independent samples t-test, p = 0.019).

**Quality of clinical outcomes.** Infection, nonunion and malunion were evaluated using the quality score system. The poor quality of the reporting of clinical outcomes is shown in Table VII. Of the 15 articles studied, 42 of 69 outcomes reported (60%) had no information at all and scored 0 points. Only two (2.9%) had information regarding the type of fracture and scored 1 point. There were 14 (20%) which scored 2 points, including information regarding the type of fracture and soft-tissue condition. Only two (2.9%) had information regarding the type of fracture, the type of reduction and fixation (open or closed), scoring 3 points.

**Discussion.** Orthopaedic studies in general are not prospective and are neither controlled nor randomised. This is unfortunate, but is an understandable consequence of the particular nature of orthopaedic trauma. Ethical considerations make it difficult to design clinical studies which have reliable and quantifiable endpoints. Many researchers have developed indices aimed at assessing the quality of individual studies, reviews or meta-analyses focusing mainly on the design of the study. However, the evaluation of a therapeutic intervention based on the results of a comprehensive

**Table I.** Demographic characteristics of the study population (group A, spanning frames; group B, sparing frames)

<table>
<thead>
<tr>
<th>Age in yrs (range)</th>
<th>Group A (179 fractures)</th>
<th>Group B (286 fractures)</th>
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<tr>
<td>39.5 (17 to 74)</td>
<td>40.8 (15 to 83)</td>
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**Table II.** Observation of statistically insignificant correlation between the year of the study and its quality

<table>
<thead>
<tr>
<th>Author/s</th>
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<tr>
<td>Bone et al</td>
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<td>Mitkovic et al</td>
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<td>Okcu and Aktoglu</td>
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* 61 fractures were unclassified by the authors
† 48 fractures were unclassified by the authors
individual study is hindered when the results are expressed in single words or vague general terms. The majority of orthopaedic surgeons agree that open fractures, or closed fractures with severe soft-tissue damage, are associated with increased rates of infection and nonunion.\textsuperscript{30,31} Open reduction and minimal internal fixation may improve the rates of malunion. However, the majority of reports do not specify whether the clinical outcome concerns a patient who sustained an open or closed fracture, or underwent closed or open reduction, with or without limited internal fixation. The quality of reporting of results is extremely variable and we therefore devised a scoring system to assess the quality of reports of clinical outcome.

We evaluated publications describing a wide variety of fractures and methods of management. Of these studies, 60\% (42 outcomes) of the clinical outcome evaluated had no information regarding the components of the outcome report scoring system. We were therefore not able to evaluate the efficacy of the various therapeutic interventions because of the heterogeneity of the studies and the paucity of the data reported.

Minor infections were significantly more common in group B compared with group A, and the majority were pin track infections. Although the authors did not distinguish between pin and wire infections, the placement of the pins or wires in association with a haematoma, oedema and a bloody or serous effusion, predisposes to contamination by various types of bacteria. Contamination may progress deeper, following the direction of the pins to adjacent screws or plates, or to joint surfaces, raising the possibility of osteomyelitis.
of deep infection. Weiner, Mirsky and Karas had three deep infections (3.5%) after treating fractures of the tibial plateau with hybrid frames and minimal internal fixation when the Kirschner wires of the external fixation were placed close to the screws. Three deep infections (13%) were also observed by Stamer et al, who treated fractures of the tibial plateau with combined hybrid external and internal fixation. In our analysis, major infections were no more frequent in the hybrid group (2.7%) than in the group treated by frames bridging the ankle (3.9%), although many of the authors in both groups treated pilon fractures with a combination of external and minimal internal fixation.

The incidence of septic arthritis in fractures of the tibial plateau and plafond treated with hybrid frames is 1% and 0.5% respectively. Hutson and Zych observed that such infections were caused by wires placed close to subchondral bone. Weiner et al had two cases of septic arthritis after treatment of tibial plateau fractures with hybrid frames. In both, the tensioned wires were less than 10 mm from the knee joint. However, Marsh, Smith and Do noted two cases of septic arthritis when treating fractures of the tibial plateau with hybrid frames, and in both, the tensioned wires were placed more than 30 mm from the articular surface. In our study, the incidence of septic arthritis using hybrid frames was 0.6%, similar to that seen by Hutson and Zych. There is not sufficient data to demonstrate any relationship between the position of the wires and septic arthritis.

The incidence of nonunion was similar in both groups, indicating that each system provides adequate immobilisation of the fracture. Other factors influencing nonunion

<table>
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<tr>
<th>Authors</th>
<th>Number of fractures</th>
<th>Number of C-type fractures (^{19,29})</th>
<th>Open fractures</th>
<th>ORIF*</th>
<th>Tibular fixation</th>
<th>Malunion</th>
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<td>Total</td>
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<td>169</td>
<td>69</td>
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<td>Total</td>
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<td>118</td>
<td>58</td>
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* ORIF, open reduction and internal fixation
such the extent of soft-tissue damage, the amount of minimal internal fixation performed and the implantation of bone grafting, could not be evaluated.

Malunion was statistically more common in patients treated with frames spanning the ankle joint (group A) than in those sparing the ankle (group B). It seems that the spanning frames were not sufficient to maintain the initial reduction, as the pins were placed far from the site of fracture, leaving only ligamentotaxis to provide the essential stabilisation of the fragments. Plating the fibula may prevent malunion of the tibia, although Williams et al found no statistically significant differences between plafond fractures treated with bridging frames, with or without plating of the fibula. With hybrid frames the wires are placed at the fracture site, connecting and compressing the fragments and providing better stabilisation compared with ligamentous tension.

Immobilisation by spanning frames may have detrimental effects on movement of the ankle joint. However, Bone et al observed a satisfactory range of movement in patients treated with spanning frames, suggesting that it may be the result of joint distraction and stretching of the ligament during the period of immobilisation, preventing compression and shortening of the ligaments which might lead to stiffness and restriction of movement. The significantly greater degree of plantar flexion observed in patients treated with hybrid frames was expected, since inappropriate placement of the articulating component in spanning frames may compromise movement of the ankle. Movements away from the centre of rotation of the ankle may be the cause of pin loosening, pain and restriction of movement.

There does not appear to be large differences in outcome between spanning or sparing frames in the treatment of fractures of the plafond fragment from the incidence of malunion. However, given the scientifically weak quality of reporting of clinical outcome, it is unclear whether the higher rate of malunion is a true disadvantage of spanning frames or the result of other factors.

We would like to thank Mrs M. Pateromichelakis, MD, and T. Tosovnidis, MD, for their contribution concerning the preparation of the paper.

References