

Seminal papers in orthopaedic trauma

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Abstract

Over recent decades, the concept of Evidence-Based Medicine has come to form the cornerstone of clinical practice in all medical specialities, including Trauma and Orthopaedic Surgery. Management of the trauma patient is part of everyday practice for most Orthopaedic Surgeons. As such, it is important to be aware of the seminal research studies that have informed current clinical practice. It is also important that all surgeons, including surgeons-in-training, follow the process of ongoing professional development such that their clinical practice remains current and up to date. In this article, we critically evaluate a number of important research papers, which have been selected for their impact on contemporary clinical practice, recognized in many orthopaedic teaching programmes.

Keywords classic; literature; orthopaedics; trauma

Introduction

The management of orthopaedic conditions has undergone a dramatic evolution over recent decades. Evidence-based medicine has developed to form the cornerstone of most clinical specialities and has informed and guided Orthopaedic research and practice. This has resulted in an expansion in the volume and variety of research being undertaken and published. Historically, peer reviewed publications predominantly comprised cohort studies, case series and expert opinion. With the evolution of contemporary research methodology, we now see meta-analyses, systematic reviews and randomized control trials as the tip of the evidence-based pyramid.¹ A critical feature of

evidence-based medicine is the pathway for dissemination of research findings amongst peers. The commonest methods of dissemination include presentations at learned societies and publication in medical journals. Orthopaedic speciality journals only became widely available in the late 1940s. In recent years, the number of journals and the frequency of their publication have increased.²

Trauma management makes up a large portion of the practice of most orthopaedic surgeons and is widely researched. As a consequence, there is a large volume of research material available. It is important for practicing surgeons to be familiar with the seminal orthopaedic papers that have underpinned much of our current practice, and familiarity with such seminal work undoubtedly puts the prospective candidate for final professional examinations in good stead.

To this end, we present this review of influential papers (Table 1) using established critiquing techniques,³ with a specific emphasis upon the relevance to current practice. These papers have been selected for their importance within practice and their influence in teaching.

Paper 1 - Operative compared with nonoperative treatment of displaced intra-articular calcaneal fractures: a prospective, randomized, controlled multicenter trial

Buckley R, Tough S, McCormack R, Pate G, Leighton R, Petrie D, Galpin R. *J Bone Joint Surg Am* 2002; **84-A**: 1733–44.

Level of evidence: I (prospective randomized clinical trial).

Aim

To determine whether open reduction and internal fixation of displaced intra-articular calcaneal fractures results in better general and disease-specific health outcomes at 2 years post-injury than non-operative management.

Methods

Prospective randomized controlled clinical trial with patients being recruited at 4 different trauma centres. Patients who met the inclusion criteria were randomized to either operative or non-operative treatment. The operative treatment protocol involved a lateral approach with open reduction and internal fixation of the fracture. The non-operative protocol involved symptomatic management with no attempt at closed reduction. In the operative group fractures were classified, as was the quality of the reduction achieved. SF-36 scores and Visual Analog Scale (VAS) scores were used to assess general and disease-specific outcomes respectively.

Results

Between 1991 and 1997, 512 patients with calcaneal fractures were treated. 424 patients with 471 calcaneal fractures were included in the study. 390 (73%) patients were followed-up at regular intervals for a minimum of 2 years. If the non-operative and operative groups were broadly assessed, there was no clear difference in their outcome in terms of SF-36 and VAS scores.

However, when the patient groups were stratified, the outcomes appeared to be different between the operative and non-

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Summary of papers reviewed

Authors	Journal	Year	Pathology	Evidence level
Buckley et al	J Bone Joint Surg Am	2002	Calcaneal fractures	1
Khan et al	J Bone Joint Surg Am	2005	Achilles tendon ruptures	1
Lauge-Hansen	Arch Surg	1950	Ankle fractures	1
Gustilo et al	J Bone Joint Surg Am	1976	Open fractures	2 & 3
Gustilo et al	J Trauma	1984	Open fractures	3
Keating et al	J Bone Joint Surg Am	1997	Intramedullary nailing	1
McQueen et al	J Bone Joint Surg Br	1996	Compartment syndrome	2
Court-Brown et al	J Bone Joint Surg Br	1996	Intramedullary nailing	2
COTS	J Orthop Trauma	2006	Intramedullary nailing	1
Schatzker et al	Clin Orthop Relat Res	1979	Tibial plateau fractures	4
Garden	J Bone Joint Surg Br	1961	Femoral neck fractures	4
Parker et al	J Bone Joint Surg Br	2010	Femoral neck fractures	1
Bentley	J Bone Joint Surg Br	1968	Femoral neck fractures	4
Baumgaertner et al	J Bone Joint Surg Am	1995	Proximal femoral fractures	3
Duncan et al	Instr Course Lect	1995	Periprosthetics fractures	4
Dias et al	J Bone Joint Surg Am	2005	Scaphoid fractures	1

Table 1

operative groups. Once the group of patients receiving Workers' Compensation were excluded, those who were managed operatively had higher satisfaction rates ($p = 0.001$).

Women who were treated operatively also had higher satisfaction rates ($p = 0.015$). In addition, young patients not receiving Workers' Compensation and who had a moderately lower Bohler's angle ($0-14^\circ$), a comminuted fracture, light workload or anatomic reduction (post-surgery) had higher outcome scores when managed operatively.

Discussion

Without excluding the Workers' Compensation group, there was no clear significant difference in the outcome scores between the operative and non-operative groups. Patients receiving Worker's Compensation had consistently lower outcome scores. The study highlights the fact that both non-operative and operative treatments are valid options in managing patients with displaced intra-articular fractures.

Critique

The study has a clearly defined aim and utilizes a well-structured multicentre randomized trial methodology. Appropriate statistical analyses were used, which included *a priori* power calculations and interim sample size calculations during the course of the study. The study reports a 'negative result', i.e. there was no overall difference between operatively and non-operatively treated calcaneal fractures.

The study also highlights the issue of Workers' Compensation when attempting to analyse subjectively reported outcomes in trauma patients. In addition, the authors describe the important patient factors (e.g. smoking) that should be considered when making treatment choices with these patients.

It is important to note that a variety of surgical techniques were used in the operatively treated patients, predating contemporary locking plate techniques. Also, the validity of the

outcome measures, namely VAS, has not been fully reproduced by other authors. Some patients were also excluded during the course of the study; for example, non-operatively treated patients who needed a subtalar fusion within two years were excluded. The outcome of such patients is an important factor to consider when managing calcaneal fractures non-operatively.

Key points

Patient factors such as smoking and occupation should be taken into consideration when determining whether to treat displaced calcaneal fractures operatively or non-operatively. Women, younger patients and those with a lighter workload have better outcome scores after surgical management.

Relevance to current practice

An ideal algorithm for treating displaced intra-articular fractures is unlikely to ever be described. This study highlights the important patient factors to consider. It is also important that calcaneal fractures are treated by surgeons experienced in their management. The recently completed UK Heel Fracture Trial⁴ will hopefully provide us with more information on how to best treat this complex injury.

Paper 2 - Treatment of acute Achilles tendon ruptures: a metaanalysis of randomised, controlled trials

Khan RJK, Fick D, Keogh A, Crawford J, Brammar T, Parker M. *J Bone Joint Surg Am* 2005; **87-A**: 2202–10.

Level of evidence: I (meta-analysis).

Aim

To summarize the evidence from randomized control trials on the effectiveness of different interventions in the treatment of acute Achilles tendon ruptures. The factors that are investigated include non-operative (cast or functional brace) and operative

(open or percutaneous repair) treatment, as well as post-operative splinting (cast or functional brace).

Methods

Multiple databases (including MEDLINE, EMBASE and CINAHL) were searched for randomized controlled clinical trials, quasi-randomized studies and studies where patients were inadequately concealed. Search terms used included Achilles tendon, ruptures and tendon injuries. In addition, reference lists of articles were also searched and, in some cases, authors were contacted. Retrospective studies and some unique randomized studies, where pooling of data was not possible, were excluded. Three reviewers analysed the studies and determined the quality of the trials with the use of a ten-item scale.

Results

800 patients in 12 studies were included. Operative treatment carried a lower risk of rerupture (3.5%) in comparison to non-operative treatment (12.6%) with a relative risk of 0.27. The rate of rerupture was also lower in the open repair group (2.1%) versus the percutaneous repair group (4.3%). With regards to complications (excluding rerupture), the rate was 34.1% in the operative group and 2.7% in the non-operative group (relative risk 10.6). The rate of complications (excluding rerupture) was lower in the percutaneous repair group (8.3%) in comparison to the open repair group (26.1%) with a relative risk of 2.84. Post-operative rehabilitation with a functional brace was also associated with a reduced risk of complications in comparison to cast treatment (relative risk 1.88).

Discussion

Operative repair is associated with a reduced risk of rerupture but an increased complication rate. Percutaneous repair techniques help mitigate some of the complications. In addition, post-operative splinting with a functional brace, rather than casting, is also associated with a reduced complication rate. With regards to non-operative treatment options, the total number of patients was too small and, therefore, definitive conclusions could not be drawn.

Critique

This is a well-designed meta-analysis that identified appropriate studies for analysis. Studies were then scored according to their methodological rigour. Data was pooled in order to facilitate statistical analysis. Due to small numbers of patients in some trials, a number of the conclusions from the study need to be carefully considered, such as the observation that percutaneous repair has a lower complication rate than open repair.

The main consequence of pooling data is that a variety of regimens and interventions are grouped together to facilitate the analysis, but this limits the validity of the conclusions. In addition, the study did not assess the functional outcome of non-operative and operative treatments.

Key points

Achilles tendon ruptures can be treated non-operatively or operatively. It is important to discuss the treatment options with the patient so that they are fully aware of the risks. The activity level

of the patient should also be taken into account. Although operative repair carries a lower rerupture rate than non-operative treatment, this is at the expense of an increased complication rate.

Percutaneous repair can help mitigate some of the operative risk although it is a technically demanding procedure. This study also highlights the importance of rehabilitation with a functional brace rather than cast immobilization.

Relevance to current practice

This study has long been used as a guide to managing acute Achilles tendon ruptures. It has fostered an approach of operative treatment for young, active individuals while older and less active individuals are managed non-operatively. Interestingly the authors, in their study, found that patients treated non-operatively with functional bracing had similar rerupture rates to those treated with open repair. Although the authors felt that this appeared to be a spurious result, it has been reproduced in more recent well-designed randomized controlled trials.^{5,6}

As a consequence, there has been a shift in approach with more Achilles tendon ruptures being managed non-operatively with functional bracing⁵ and an avoidance of surgical complications. Studies supporting this treatment strategy also describe comparable functional outcome scores between non-operative and operative groups.

Paper 3 - Fractures of the ankle. II Combined experimental-surgical and experimental-roentgenologic investigations

Lauge-Hansen N. *Arch Surg* 1950; **60**: 957–85

Level of evidence: I (basic science study).

Aim

To determine the mechanism of injury for ankle fractures, describe their pathoanatomy and radiographic pattern.

Methods

Fresh lower limb specimens were obtained from patients undergoing amputation surgery and were wrapped, then experiments undertaken within a few hours. Fresh specimens were preferred to cadavers to avoid rigour mortis. The specimens were then held in place with a vice and nails placed strategically around the lower limb. Deforming forces were then applied by hand, leading to fractures of the ankle.

The specimens underwent radiological investigation and were then dissected to investigate the pattern of bone and ligamentous injuries that were sustained. As a result of this method of investigation, the fracture patterns are described with a dual designation. The first term describes the foot position at the time of injury and the second term describes the direction of the deforming force.

Results

Initial examination of the fresh specimens confirmed that full, free passive movement was present in the foot and ankle. The composite movements of supination and pronation are assessed and described. Supination is a combination of hindfoot adduction, forefoot inversion and internal rotation. Pronation is a combination of hindfoot abduction, forefoot eversion and

external rotation. The specimens were then held in either maximal foot supination or pronation. Forced adduction and forced eversion were then applied to the supinated foot in a number of separate experiments. Forced abduction and forced eversion were then applied to the pronated foot in a similar fashion. Forced adduction and abduction applied to the supinated and pronated foot respectively led to initial fractures or ligamentous injuries on the tension side and secondary fractures on the compression side. Eversion to either the pronated or supinated foot showed complex circumferential fracture patterns with or without additional ligamentous injuries.

Discussion

These experimental studies illustrate the variety of injuries commonly seen in clinical practice and facilitate a thorough understanding of the injury mechanics. The study also allows one to recognize the mechanism of injury by reviewing the radiographic images. By understanding the importance of the initial foot/ankle position and the direction of deforming force, fractures can be anatomically reduced.

Critique

This pioneering study was the first to illustrate and study the critical issues of initial foot position and the deforming force vector. There are a number of methodological issues that need to be appreciated. The total number of specimens used is not clear. In addition, the mechanism of application of the deforming force is by hand, which does not truly recreate the high energies involved in some traumatic fractures. In such high energy injuries, there is an increased soft tissue injury component, rendering the ankle more unstable and more difficult to reduce. Nonetheless, the importance and impact of this study cannot be understated.

Key points

With an understanding of this paper, one can review the radiographs and determine the fracture type. As a result, the foot can be placed in the original supinated or pronated position, and the fracture reduced by applying a force that is in the opposite direction to the implied original deforming force.

Relevance to current practice

The Lauge-Hansen ankle fracture classification system is used by many surgeons in their day-to-day practice. Although more complex than a number of other simpler ankle classification systems, it is more sophisticated and more relevant to fracture management. It illustrates the pathomechanics of ankle fractures and facilitates anatomical fracture reduction.

Paper 4 - Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses

Gustilo RB, Anderson JT. *J Bone Joint Surg Am* 1976; **58-A**: 453–58.

Level of evidence: II and III as the study had prospective and retrospective elements

Aims

To determine whether the following variables affected rate of infection in open fractures:

- Primary versus secondary closure;
- Use of primary internal fixation;
- Use of antibiotics.

Methods

This article presents a combined retrospective and prospective study.

The retrospective study identified 673 open fractures treated over 14 years. 87% of the patients were followed-up for 1 year. A standardized management protocol was used for treating the open fractures. This included debridement, irrigation, primary closure where possible, post-operative antibiotics and optional internal fixation.

The prospective study identified 352 fractures managed over 4 years. The fractures are classified and labelled as either type 1, 2 or 3. The standardized management protocol includes obtaining a wound swab, peri-operative antibiotics, debridement, irrigation and primary closure for type 1 and 2 injuries.

Results

In the retrospective arm of this study, the overall infection rate is 6.5%. However, there was also a clear change in the infection rate during the course of this study. Between 1955 and 1960, the infection rate was 11% but fell to 5% between 1961–1968 after introduction of the regular use of antibiotics. The main organism was *Staphylococcus aureus*. The infection rate was found to be higher in those with internal fixation, secondary wound closure, significant soft tissue injury, traumatic amputations and segmental fractures.

In the prospective arm of the study, the vast majority of injuries were type 1 and 2 open fractures. The infection rate was only 2.4% and this is significantly less than the infection rate noted in the retrospective arm. The majority of patients also had a positive wound swab from the open fracture site, highlighting the increased risk of infection.

Discussion

The study highlights the risk of infection associated with open fractures. However, a standardized approach to treatment can help reduce the infection rate. The study identified important aspects to consider when treating open fractures:

- Type 1 and 2 injuries should ideally undergo primary closure;
- Type 3 fractures should be treated with initial debridement and delayed closure;
- Avoid internal fixation;
- Skeletal traction for open fractures with concurrent arterial injuries;
- Peri-operative antibiotics.

Critique

The purpose of the study was clearly documented. Patient groups were not demographically matched and injuries were not

stratified in the retrospective group. A standardized management protocol was used but not always followed. Although there was no detailed statistical analysis, this study utilized cohorts with large patient numbers allowing appropriate conclusions to be drawn.

Key points

Open fractures are associated with an increased risk of infection (Figure 1). When treating open fractures, a number of factors need to be considered, which contemporaneously would include:

- Attempt to close type 1 and 2 open fractures;
- Treat type 3 injuries with initial debridement and delayed wound closure;
- Use peri-operative antibiotics.

Relevance to current practice

This is an important paper that has contributed to contemporary open fracture management guidelines. The principles highlighted above are used by surgeons throughout the world when managing open fractures, and have helped in the development of the BOAST guidelines⁷ for open fractures in the UK.

Paper 5 - Problems in the management of type III (severe) open fractures: a new classification of type III open fractures

Gustilo RB, Mendoza RM, Williams DN. *J Trauma* 1984; **24**: 742–46.

Level of evidence: III (retrospective cohort).

Aim

To identify the factors associated with increased morbidity in type 3 open fractures. In addition, type 3 open fractures were subclassified.

Methods

Between 1976 and 1979, the notes and radiographs of patients presenting with type 3 open fractures were reviewed. The details

of wound and fracture healing, as well as all complications developing, were recorded. The classification system developed to stratify type 3 open fractures is shown below:

Type IIIA – adequate soft tissue coverage of a fractured bone, despite extensive soft tissue laceration or flaps. Alternatively, high energy trauma irrespective of the size of the wound.

Type IIIB – extensive soft tissue injury with periosteal stripping and bone exposure. This is usually associated with massive contamination.

Type IIIC – open fracture associated with arterial injury requiring repair.

A similar management protocol was used to that described in the authors' original study.⁸

Results

75 patients, predominantly male, with 87 type 3 open fractures were included in the study. The age ranged from 11 to 83 years (mean 33.1 years). Motorcycle accidents were the commonest cause of injury. The tibia and fibula were the commonest bones injured. Five patients died early as a result of multi-system trauma leaving, 82 fractures for analysis.

Fractures were stabilized initially or at repeat debridement (24–48 h post-injury). The means of stabilization included plaster of Paris with or without pins, external fixation or internal fixation. There was an increased incidence of infection and amputation in type IIIC fractures (42% in both cases) in comparison to type IIIA injuries (4% and 0% respectively).

With respect to wound infections, the commonest organisms found were Gram-negative bacteria, which is in contrast to the previous study where *Staphylococcus aureus* was the commonest organism.⁸ In terms of bone healing, there was an increased risk of delayed union with displaced fractures.

Discussion

This study highlights the factors that are associated with an increased risk of complications. The development of the



Figure 1 Clinical photographs illustrating several type 3 open fracture wounds involving the lower limb.

subclassification allows stratification of type 3 open fractures to indicate worsening prognosis. The study provides evidence that the new classification system has validity in the clinical setting.

Critique

This retrospective study fulfilled its aim of identifying factors that led to complications in type 3 open fractures. There was no control group, e.g. patients with closed injuries and severe fracture patterns, to allow comparative analysis. A standardized management protocol was used in the study. There was little statistical analysis, which was common amongst studies at that time. Nonetheless, this study was pivotal because it described the risk factors associated with an increased morbidity.

Key points

Open fractures are commonly associated with complications, particularly if there is:

- Massive soft tissue damage;
- Severe wound contamination;
- Impaired vascularity, and
- Fracture instability.

The subclassification of type 3 open fractures allows the above risk factors to be assessed in order to predict the increased risk of complications. The study also highlights the important tenets of open fracture management, which include:

- Early diagnosis, aggressive and repeated debridement;
- Leaving wounds open;
- Prompt and vigorous antibiotic therapy;
- Ensuring fracture stability;
- Early cancellous bone grafting;
- Appropriate wound closure.

Relevance to current practice

Despite newer classification systems being devised,⁹ this classification system remains widely used in contemporary practice, both in clinical and research settings. This study helped revolutionize open fracture treatment at a time when complications were common. The impact of this study is still being felt today, as new open fracture management guidelines⁷ hinge on evidence from this study and similar that preceded and followed it.⁸

Paper 6 - Locking intramedullary nailing with and without reaming for open fractures of the tibial shaft. A prospective, randomized study

Keating JF, O'Brien PJ, Blachut PA, Meek RN, Broekhuysen HM. *J Bone Joint Surg Am* 1997; **79-A**: 334–41.

Level of evidence: I (randomized clinical trial).

Aims

To determine if there were any differences in clinical and radiographic outcomes following reamed and unreamed intramedullary tibial nailing.

Methods

This study was an unblinded, randomized controlled clinical trial. Patients were recruited into the study over a 4-year period

from 1989 to 1993 and all grades of open fracture were included. Randomization was completed with a sealed-envelope selection technique. Patients were either allocated to nailing without reaming or nailing with reaming.

There were a number of exclusion criteria, which included patients presenting more than 24 h after the injury, children and those whose fractures were not amenable to nailing. Operations were undertaken or supervised by the senior authors. All patients received standardized pre-operative antimicrobial medications and had similar post-operative rehabilitation schedules. Technical details of the operative procedure were recorded, including blood loss, fluoroscopy time, time for insertion of the nail and other parameters.

Wounds were not closed primarily. Early peri-operative complications were documented, including compartment syndrome, fat embolism and pulmonary embolism. Patients were followed-up on a regular basis until union. Failure of an implant or further interventions that were required and episodes of infection (superficial and deep) were recorded. Basic functional outcomes, radiological outcomes and clinical examination findings were also documented.

Results

100 open fractures in 97 patients were initially considered for entry into the study. Six patients were later withdrawn due to death or anatomical considerations that caused significant changes to their operative treatment strategy. Therefore, 94 fractures in 91 patients were included in the study. 50 fractures (48 patients) were randomized to reamed nailing and 44 fractures (43 patients) were allocated to the unreamed nailing group. The average patient age was 37 years, the majority of the patients being male. Both groups had similar characteristics in terms of their demographics, fracture site location, degree of comminution and Gustilo & Anderson grade.^{8,10} The overall average diameter of the unreamed nails was 9.2 mm and 11.5 mm in the reamed nailing group.

There was no difference between the two groups in rates of compartment syndrome, pulmonary/fat embolism, infection, non-union, malunion, fixation failure, mobility, anterior knee pain and ability to return to work. There was a trend towards an increased rate of union in the reamed nailing group but this was not significant. The only significant finding was an increased rate of screw breakage in the unreamed nailing group.

Discussion

This study demonstrates no significant difference in the rate of post-operative complications and long-term functional outcomes. The finding that union rates were not reduced in the reamed nailing group may suggest that blood flow to the site of the fracture recovers despite the loss of the endosteal circulation. Therefore, the endosteal circulation may itself be less critical to bone healing than previously thought.

An increase in the number of screw breakages was noted in the unreamed nailing group. This finding is fairly intuitive because thinner nails tend to confer less biomechanical rigidity. However, there was no increase in the rate of malunion or non-union. The findings of this study also suggest that adequate debridement of

soft tissues and bone, with appropriate soft tissue cover, are important factors that facilitate union and avoid infection.

Critique

This was the largest study of its type at the time of publication. It was a well-constructed, randomized clinical trial that set out to answer specific questions. The inclusion and exclusion criteria were minimal in order to limit selection bias. The intention to treat is clear, with significant efforts being made to follow-up the study participants. All withdrawals were explained. A power calculation was not undertaken at any point. Nonetheless, this study was an important paper at a time when reamed intramedullary nailing was felt to be an inappropriate treatment for open fractures.

Key points

Reamed intramedullary nailing of open fractures did not increase the rate of infection or the rate of delayed/non-union in open fractures when compared to unreamed nailing. Indeed, other factors may be more important and special consideration should be given to the management of dead space and soft tissue reconstruction techniques.

Relevance to current practice

This large study provides evidence for the technique of reamed intramedullary nailing in open tibial fractures. It highlights the importance of soft tissue handling and soft tissue cover in helping to mitigate the risk of infection and delayed/non-union. Despite the study not being powered, it has provided the basis for future studies, which have expanded on the findings from this study. More contemporary research¹¹ has questioned the benefit of reamed intramedullary nailing in open fractures.

Paper 7 - Compartment monitoring in tibial fractures: The pressure threshold for decompression

McQueen MM, Court-Brown CM. *J Bone Joint Surg Br* 1996; **78-B**: 99–104.

Level of evidence: II (prospective cohort study).

Aim

To determine whether surgical decompression (fasciotomy) should be performed when the tissue pressure rises to within 30 mmHg of the diastolic blood pressure [delta-P = tissue pressure – diastolic blood pressure].

Methods

Patients were recruited over a period of 2 years and 7 months at a single centre. The patients underwent continuous anterior compartment pressure monitoring for a total of 24 h with separate analysis for the first 12 h and the second 12 h. Patients were followed-up for an average of 15 months to assess for any late sequelae of compartment syndrome.

Results

116 patients were recruited for entry into the study. There were a total of three patients who developed compartment syndrome.

The average delta-P of all patients was 52 mmHg for the first 12 h and 56 mmHg for the second 12 h.

Within the first 12 h, 87 patients had absolute pressures higher than 30 mmHg. Only one patient had a delta-P within 30 mmHg of the diastolic pressure. As a consequence, this patient underwent fasciotomy.

In the second 12 h, 37 patients had absolute pressures higher than 30 mmHg. In this group, the delta-P of two patients was within 30 mmHg of the diastolic pressure. As a result, these two patients underwent fasciotomy. Further analysis of the results showed that higher energy injuries were associated with a lower delta-P ($p < 0.002$). Fracture grade (measured by Tscherne grade) had a strong correlation with delta-P. Delta-P was also lower when there was a delay to surgery. There was no correlation between open vs. closed fractures or fixation method with the delta-P. No patients demonstrated any long-term sequelae at follow-up.

Discussion

Absolute compartment pressure is an unreliable indicator for compartment syndrome and would lead to too many false positives. Using a delta-P level within 30 mmHg of the diastolic pressure was accurate in diagnosing all cases of compartment syndrome, with no missed cases. The study findings suggest that if the delta-P is greater than 30 mmHg, fasciotomy is not required but continued monitoring is necessary.

Another important finding of the study is that there was no difference in pressures between open and closed injuries. This finding suggests that open fractures do not decompress the compartments as previously thought. The study also demonstrates that a delay to theatre (more than 24 h) is associated with increased compartment pressures.

Critique

This is a well-designed prospective study that effectively answers an important clinical question. Although compartment syndrome is not a very common condition, the occurrence of only three cases makes it difficult to appreciate the validity of the conclusions. Nonetheless, based on the patient population that was used, the delta-P threshold of 30 mmHg is appropriate, as there were no missed cases. The length of follow-up was adequate to detect any occult or missed cases of compartment syndrome. The article did not provide any indication of whether the study population was recruited on a chronological basis or if there were inclusion/exclusion criteria. There was neither documentation of clinical correlation nor a clear description of pressure measuring technique. In addition, only the anterior compartment pressure was measured.

Key points

If compartment pressures are measured in tibial fractures, a delta-P of less than 30 mmHg warrants surgical decompression (fasciotomy). High energy injuries and increased fracture severity are associated with an increased risk of compartment syndrome. Compartment syndrome is as likely in open and closed fractures. Delay to surgery increases the risk of compartment syndrome. This may be due to the increased soft tissue

swelling present at the time of surgical reduction with the fracture being pulled out to length and/or the increased force required to reduce the fracture. There is no clear association between the fixation method and the risk of compartment syndrome.

Relevance to current practice

Compartment syndrome is a devastating condition, especially if the diagnosis is delayed. Clinical assessment remains the most sensitive method of diagnosing this condition. The ability to measure compartment pressures proves more useful in the obtunded patient, such as the sedated and intubated patient in the intensive care facility, when clinical assessment is not possible (Figure 2).

If pressure monitoring is considered, it is important to undertake serial readings and assess the trend rather than act on a one-off reading. It is important to appreciate that high energy fractures carry an increased risk of compartment syndrome and patients should be continually reassessed. Delays before surgery should also be minimized in order to avoid increasing the risk of compartment syndrome.

Paper 8 - Reamed or unreamed nailing for closed tibial fractures: a prospective study in Tscherne C1 fractures

Court-Brown CM, Will E, Christie J, McQueen MM. *J Bone Joint Surg Br* 1996; **78**: 580–83.

Level of evidence: II (randomized clinical trial).

Aims

To determine which method of intramedullary nailing (reamed versus unreamed) is appropriate when managing Tscherne C1 tibial fractures.

Methods

A prospective randomized clinical trial was undertaken over a one year period. Patients who presented with unilateral Tscherne C1 tibial fractures were recruited into the study. Patients were then randomized to either reamed (Grosse-Kempf) or unreamed (AO UTN) tibial nailing by the sealed-envelope method. Post-operatively, all patients followed the same rehabilitation schedule and were reviewed at 3, 6 and 12 months.



Figure 2 Clinical photograph depicting a Compartment Pressure Monitor (Stryker, Newbury, UK).

At follow-up, clinical examination was performed in order to assess the knee and ankle range of motion. The level of functional activity was also assessed, including return to work. Radiographs were also undertaken at the follow-up appointments. Time to bony union (clinical and radiological), presence of malunion, incidence of infection, rate of anterior knee pain and rate of implant failure were also recorded. Exchange nailing was undertaken if there was atrophic union at 12–14 weeks post-op, or if there was persisting evidence of hypertrophic non-union. Compartment pressures were also measured post-operatively.

Results

A total of 50 patients were recruited. They were equally and randomly allocated to the two groups. The mean time to bony union with reamed nails was 15.4 weeks, which was significantly less ($p < 0.01$) than the 22.8 weeks required for the unreamed group. Five of the unreamed cases underwent revision surgery in comparison to none in the reamed group. Unreamed nails were associated with a malunion rate of 16% and an implant failure rate of 56% (13 screw failures and 1 nail failure). In the reamed group, there were no cases of malunion and the implant failure rate was 4% (1 screw failure). The rate of compartment syndrome was similar. There were no cases of superficial or deep infection in either group. Ankle range of motion, incidence of anterior knee pain and time to return to work was similar in both groups.

Discussion

Reamed intramedullary nailing is associated with a shorter time to bony union and a lower complication rate than when unreamed nails are utilized. At 3 months, 20% of the unreamed nailing group needed a further surgical intervention. Implant failure occurred in more than half of the patients in the unreamed group. The findings of the study support the use of reamed tibial nailing for the treatment of Tscherne C1 tibial fractures.

Critique

This paper identified the heterogeneous nature of previous research that had attempted to investigate the best intramedullary nailing option for tibial fractures. The study included only Tscherne C1 fractures. The study protocol was appropriately written with a suitable randomization technique. The patient groups were demographically similar and all patients followed the same rehabilitation schedule and were followed-up for an appropriate period of time. There is no clear documentation of whether the physiotherapist reviewing the patient in the clinic was blinded to the type of nail used, neither is there a description of the seniority of the operating surgeon. Appropriate statistical analysis of the results was completed, though there was no clear power calculation undertaken prior to or after the study, which can limit the validity of the results.

Key points

For Tscherne C1 fractures, reamed tibial nailing offers a potentially shorter time to union, with a lower risk of implant failure and further surgery. Nonetheless, there was no significant difference in the rates of compartment syndrome, anterior knee pain, functional outcomes or lower limb range of movement.

Relevance to current practice

Reamed intramedullary nailing facilitates the insertion of a larger diameter nail, which provides increased mechanical stability. The increased stability helps reduce the risk of complications, such as implant failure. Further research¹¹ has continued to show the benefit of reamed intramedullary nailing in a closed fractures.

Paper 9 - Reamed versus unreamed intramedullary nailing of the femur: comparison of the rate of ARDS in multiple injured patients

The Canadian Orthopaedic Trauma Society. *J Orthop Trauma* 2006; **20**: 384–87.

Level of evidence: I (randomized controlled clinical trial).

Aim

To determine the risk of acute respiratory distress syndrome (ARDS) and mortality in multiply-injured patients with a fractured femoral shaft treated with intramedullary nailing.

Methods

This multicentre study involved 7 level I trauma centres. Specific inclusion and exclusion criteria were employed during patient recruitment. Patients presenting to these centres between 1995 and 1999 were consented then stratified according to their estimated Injury Severity Score (ISS). Individuals were assigned to either reamed or unreamed nailing by drawing sequential marked, sealed-envelopes. Demographic and injury details were recorded. Arterial blood gases were taken from all patients both pre-operatively and at designated post-operative intervals. The primary outcome measure was the rate of ARDS.

Results

315 patients with 322 femoral shaft fractures were enrolled in the study. There were seven patients with bilateral fractures. 147 patients with 151 fractures received unreamed nails. Of these patients, 46 had an ISS ≥ 18 and 101 had an ISS < 18 . 168 patients with 171 fractures received a reamed nail. Of this group, 63 patients had an ISS ≥ 18 and 105 had an ISS < 18 . The two groups (unreamed and reamed) were well-matched for age, sex and ISS.

A total of 5 patients developed ARDS. 3 patients in the multiply-injured (ISS ≥ 18) reamed nailing group of 63 patients developed ARDS. In contrast, two patients in the multiply-injured (ISS ≥ 18) unreamed nailing group of 46 patients developed ARDS. There was no significant difference in the rates of ARDS between these two groups ($p = 0.42$). There was no mortality associated with ARDS. However, there were four deaths in the patient population, two each in both the reamed and unreamed group.

Discussion

The overall incidence of ARDS in this study was lower than that published in other similar series.^{12,13} Primary stabilization of femoral shaft fractures with intramedullary nailing did not appear to increase the rate of ARDS, as had been reported in

other studies.¹³ In this study, taking into account the patient numbers, there was no significant difference in the rate of ARDS between the reamed and unreamed nailing groups. However, given the biological basis of unreamed nailing, it is still an appropriate intervention that warrants consideration in the multiply-injured patient requiring intramedullary fixation of multiple fractures.

Critique

This randomized trial seeks to answer a specific question and to that end has an appropriate primary outcome measure. Randomization was appropriately conducted within this multicentre trial. An *a priori* power calculation was completed with the effect size based on post-operative oxygen desaturation, despite the primary outcome being ARDS. When the study was completed, a *post hoc* power calculation, taking into account the observed effect size, showed that the *a priori* calculation was inaccurate. Nonetheless, the findings of this study are valid in the context of a lower rate of ARDS than that observed in other trials.¹³

Key points

Primary stabilization of femoral shaft fractures with reamed nailing (Figure 3), in multiply-injured patients, did not increase the rate of ARDS. However, the study is underpowered based up on the *post hoc* power calculation. It is important to assess the clinical and physiological parameters of the patient in order to determine the most appropriate surgical intervention.

Relevance to current practice

Reamed intramedullary nailing is the treatment of choice for femoral shaft fractures. However, in major trauma patients, it is important to assess clinical and physiological trends prior to embarking upon surgery. In some instances, patients may

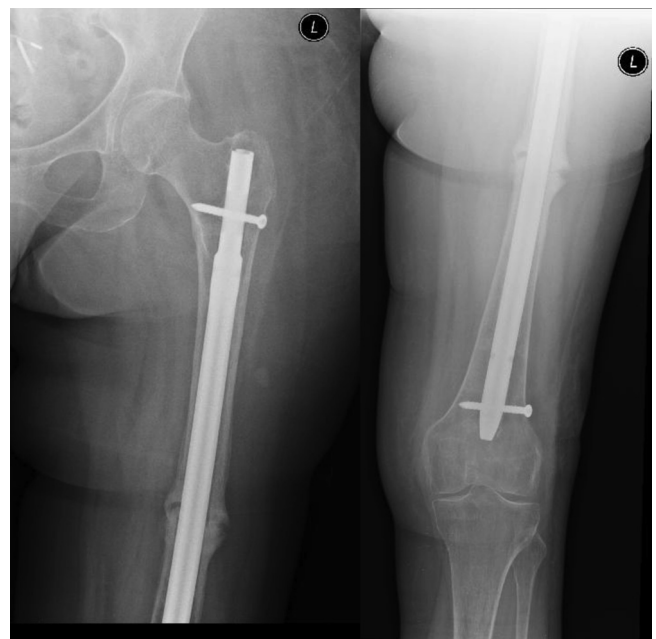


Figure 3 Post-operative radiographs of the left femur showing a femoral intramedullary nail.

require a period of time on the Intensive Care Unit in order to be resuscitated, and to allow for some physiological recovery prior to surgical intervention rather than being taken to theatre straight from the Emergency Department.¹⁴ Such goal-directed resuscitation can help mitigate some of the risks of surgery, such as acute lung injury after long bone intramedullary nailing.¹⁵

Paper 10 - The tibial plateau fracture. The Toronto experience 1968–1975

Schatzker J, McBroom R, Bruce D. *Clin Orthop Relat Res* 1979; **138**: 94–104

Level of evidence: IV (case series).

Aims

To characterize the nature of tibial plateau fractures and to determine the ideal treatment (conservative vs. operative) for a variety of different fracture patterns.

Methods

Patients presenting with tibial plateau fractures between 1968 and 1975 were included in this study. The method of treatment was recorded. Patients were followed-up with repeated clinical assessments and radiological studies. Results were grouped into the simple classification of acceptable (excellent or good) and unacceptable (fair or poor), based on clinical and radiological factors. Each fracture was also classified and then analysed in terms of average patient age, aetiology of injury, presence of osteoporosis, degree of fracture depression and overall outcome.

Results

94 fractures in 94 patients were reviewed. The majority of patients were female (60%). The average age of the study population was 57 years (range 19–89 years). 53 patients (56%) were managed without surgery and the remaining 41 patients underwent surgical fixation. Fractures were associated with other injuries of the knee. Ligamentous injuries occurred in seven patients with the anterior cruciate ligament being most commonly affected. Meniscal injuries were sustained in 16 patients, with peripheral detachment being the commonest type of injury.

In total, 53 patients (56%) were treated closed, with an average plateau depression of 5 mm for injury types 1–4. 41 patients (44%) underwent operative treatment, which included bone grafting in the majority of cases and the use of screws, bolts and plates where appropriate. The average plateau depression in the operative group was 11.4 mm. Peroneal nerve palsy was more common in the operative group, with a rate of 27% compared to a rate of 10% in the non-operative group. The nerve palsy typically resolved after several months. There were a total of 3 infections in the operative group. Type 1 fractures were typically found in younger patients secondary to high energy injury and were managed operatively if there was significant displacement. Type 2 fractures occurred in older patients, the majority being operatively managed. Type 3 fractures occurred in older patients typically due to simple falls/slips with the majority being managed closed. Type 4 fractures were either cleavage fractures or depressions of the medial tibial plateau. Cleavage fractures occurred in younger individuals due to high energy

injuries and depression fractures were the result of low energy injuries in older patients. Type 5 and 6 fractures were due to high energy injuries.

Discussion

Type 1 fractures can be managed closed unless there is significant displacement, in which case operative treatment is required. Operative treatment of type 2 fractures led to improved outcomes, as they are commonly unstable. Type 3 fractures were the commonest pattern seen in this series and required operative fixation if unstable. Type 4 fractures carried the poorest prognosis due to associated ligamentous injuries and operative treatment appeared to be a necessity for these injuries. For type 5 and 6 fractures, operative treatment appeared to confer the best chance of a satisfactory outcome.

Early motion in all fracture types was crucial in avoiding excessive stiffness, regardless of the treatment strategy employed. The presence of osteoporosis was associated with worse outcomes, which may be attributed to the increased comminution and depression seen in these injuries. Operative fixation of comminuted fractures with bone grafting, screw and buttress plate fixation led to the best outcomes. Important operative factors included appropriate soft tissue handling, maintaining bone viability and achieving anatomic reduction and rigid fixation in order to allow early motion.

Critique

This study characterized the common mechanisms of injury, patient-related factors (e.g. age) and outcomes following non-operative and operative treatment. Along with many other contemporaneous articles, this study lacks statistical rigour. However, the article is an excellent case series highlighting the different fracture patterns observed in practice and the ideal treatment strategy for each. The study also illustrates the important tenant of early joint motion following periarticular fractures.

Key points

Tibial plateau fractures can occur in both the young and old. In the young, they are associated with high energy injuries. In the old, they occur as a result of low energy injuries in osteoporotic bone. Operative treatment is required if the fracture is displaced in order to increase the likelihood of a satisfactory outcome. Regardless of the mode of treatment, early joint motion is needed in order to avoid stiffness.

Relevance to current practice

The classification system (Figure 4) used in this article is still commonly used today and helps guide treatment. Bone grafting, anatomic reduction, rigid fixation with appropriate implants and early motion are important facets when treating plateau injuries and this still applies today.

Paper 11 - Low-angle fixation in fractures of the femoral neck

Garden RS. *J Bone Joint Surg Br* 1961; **43-B**: 647–63.

Level of evidence: IV (case series).

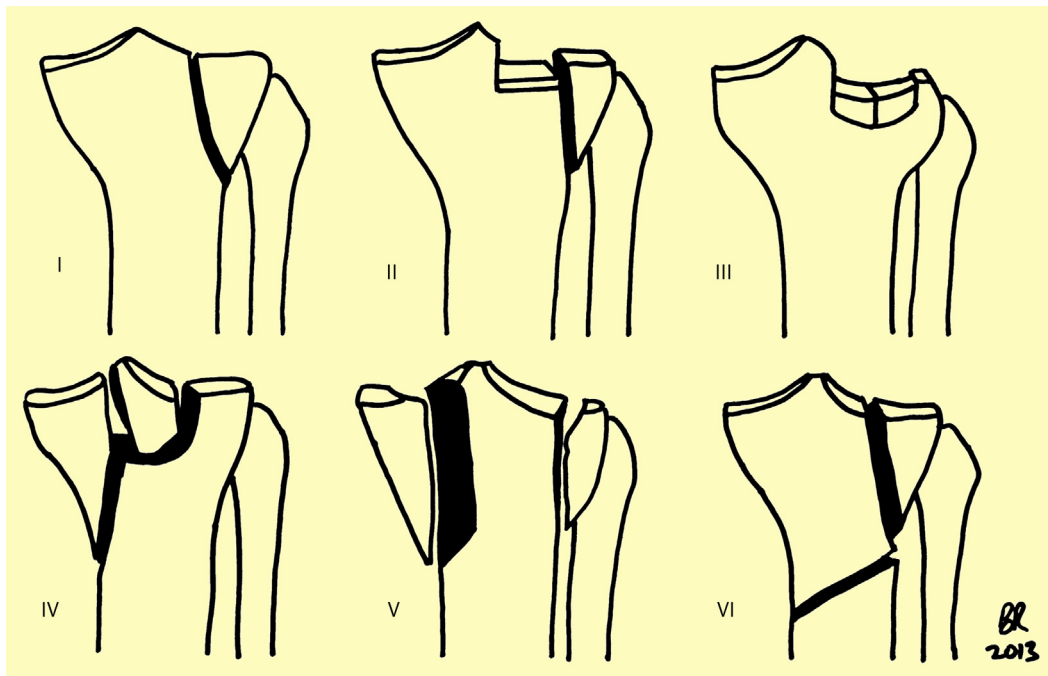


Figure 4 Diagram highlighting the Schatzker Tibial Plateau Classification System. There are six different types, each with a different fracture configuration.

Aim

To determine whether low angle fixation is an appropriate method for conferring stability to ‘fully displaced’ sub-capital fractures of the femoral neck. Another aspect of the study was to address the issue of early weight-bearing following low angle fixation.

Methods

Patients presenting to Preston Royal Infirmary, between 1955 and 1961 with femoral neck fractures were included in this study. Those with fractures above the level of the lesser trochanter were considered for low angle fixation and comprised the study population.

Results

159 patients with fractures above the level of the lesser trochanter were considered suitable for low angle fixation. Of this group, 111 patients were included in the study. Full weight-bearing was encouraged in the post-operative period. 31 of the 111 patients sustained a mid-cervical, basal, intertrochanteric or pertrochanteric fracture, which went onto union following fixation.

In contrast, the remaining 80 patients presented with sub-capital fractures that appeared to have a cumulative union rate of only 81% after fixation. When this group of patients was stratified according to the degree of initial fracture displacement (prior to any reduction), it was noted that those with ‘full displacement’ had a union rate 57%. Patients with less severe sub-capital fracture displacement patterns had union rates ranging from 93–100%.

It was also noted that the cases of non-union were associated with a poorer reduction position. Avascular necrosis was noted

to occur following union, in 11 (14%) of the 80 sub-capital fracture cases and was associated with reduction into a valgus position prior to fixation. No cases of degenerative arthritis were seen in the study but this may be associated with the relatively short follow-up period.

Discussion

The study illustrates the high union rate associated with fixation of mid-cervical, basal, intertrochanteric and subtrochanteric fractures, which is hastened by early weight-bearing. However, displaced sub-capital fractures present a difficult problem. The scoring system described in this article stratifies the severity of the initial fracture displacement prior to any reduction manoeuvre (see Table 2). Stage 4 fractures are at a higher risk of non-union after fixation in comparison to stage 1 injuries. This increased risk of non-union is due to the inherent instability of the fracture, which tends to prevent an anatomical reduction. Complications of avascular necrosis and degenerative arthritis can also be associated with non-anatomical reductions.

Highlighting the stages of the Garden classification

Stage 1	Incomplete fracture (medial trabeculae lie in abducted position)
Stage 2	Complete fracture without displacement
Stage 3	Complete fracture with partial displacement (medial trabeculae are distorted)
Stage 4	Complete fracture with full displacement (medial trabeculae are in line with those in the pelvis)

Table 2

Critique

Like many studies of its time, this case series seeks to describe a difficult clinical problem. The early part of the paper provides interesting and detailed biomechanical information on the nature of femoral neck fractures and their surgical treatments. The methodology allows the inclusion of a reasonable number of cases, allowing qualitative findings to be identified.

There is no significant statistical analysis, a common feature of research from this time. Neither is it clear which individual operated on these patients. The results of the study highlight the issues in managing unstable sub-capital femoral neck fractures with internal fixation. This pivotal paper helped produce a classification system, which remains arguably the most widely taught classification in Orthopaedics, being used throughout the world to determine the optimal surgical intervention for patients with femoral neck fractures.

Key points

Grade 4 sub-capital femoral neck fractures are associated with a very high risk of non-union after internal fixation. A non-anatomical reduction can also be associated with an increased risk of avascular necrosis and degenerative arthritis.

Relevance to current practice

As mentioned, the Garden classification system is still used to determine the optimal surgical intervention. Fortunately, developments in technology now allow us to treat stage 3 and 4 injuries with (hemi)arthroplasty options in the elderly. However, in the young, internal fixation is still the preferred choice for stage 3 and 4 injuries. This study reinforces the important tenet of anatomical reduction in order to provide the optimal conditions for union following fixation.

Paper 12 - Cemented versus uncemented hemiarthroplasty for intracapsular hip fractures: A randomised controlled trial in 400 patients

Parker MI, Pryor G, Gurusamy K. *J Bone Joint Surg Br* 2010; **92-B**: 116–22.

Level of evidence: I (randomized controlled clinical trial).

Aims

To determine if there is any difference in outcome when patients with a displaced intracapsular neck of femur fracture are treated with either a cemented Thompson prosthesis or an uncemented Austin-Moore prosthesis.

Methods

A prospective randomized clinical trial was undertaken. Over a five-year period, patients with a displaced intracapsular neck of femur fracture were randomized by the sealed opaque numbered envelope method. Pre-operatively, patients were assessed for their physical and mental status as well as their mobility level and residential status. Patients then underwent the allocated operation with standardized techniques and peri-operative protocols.

Patients were seen in the follow-up clinic 6-weeks after surgery by a nurse. Further follow-up assessment was undertaken

by a nurse and completed over the telephone at 3, 6 and 12 months then yearly for up to 5 years. If patients were not contactable, their GP and/or next of kin were contacted. During the follow-up assessments, patients were assessed for their level of symptoms and functional activity level. A power calculation was completed prior to the start of the study.

Results

A total of 400 patients were recruited into the study. They were equally and randomly allocated to one of two comparable groups, which was either treatment with a cemented Thompson hemiarthroplasty or an uncemented Austin-Moore hemiarthroplasty. The average age of the patient population was 83 years with the majority (77%) being female. 11 patients in each group were not treated as per protocol for a variety of reasons. There was no difference in the rate of blood transfusion between the two groups. The length of stay was less for the cemented hemiarthroplasty group.

There were no significant differences in the rate of implant-related complications, re-operations, general medical complications or mortality between the two groups. Post-operatively, the ability of patients to complete their activities of daily living was also comparable between the two groups. The degree of residual pain was less in the cemented hemiarthroplasty group, although this was only significant between 3-months and 1-year. The level of mobility was higher in the cemented group with significance being reached between the 6-months and 1-year time point.

Discussion

The results of this study suggest that cemented Thompson hemiarthroplasty led to less pain, a reduced length of stay and improved mobility in comparison to an uncemented Austin-Moore hemiarthroplasty. There was no evidence for an increased complication rate or mortality rate in association with cement.

Critique

This was the largest randomized trial, at the time of publication, on this topic. This study was well-structured with appropriate blinding where possible. Appropriate inclusion and exclusion criteria were utilized during patient recruitment. The sealed opaque envelopes were selected by an independent person not associated with the study, which helped minimize selection bias. The nurse who followed-up the patients was blinded to the implant in order to minimize observer bias. An *a priori* power calculation was completed, with residual pain used as the primary outcome measure. However, in both groups, a number of patients were found not to be suitable for the intervention to which they were allocated. There was also a significant loss to follow-up in both groups that is not clearly accounted for in the power calculation. It is important to note that the Thompson and Austin-Moore implants have very different design rationales, which may account for the observed differences in addition to any benefit conferred by cementation, which in itself helps to provide a more stable construct in osteoporotic bone.

Key points

Cemented Thompson hemiarthroplasty confers benefits in terms of less residual pain and improved mobility in comparison to

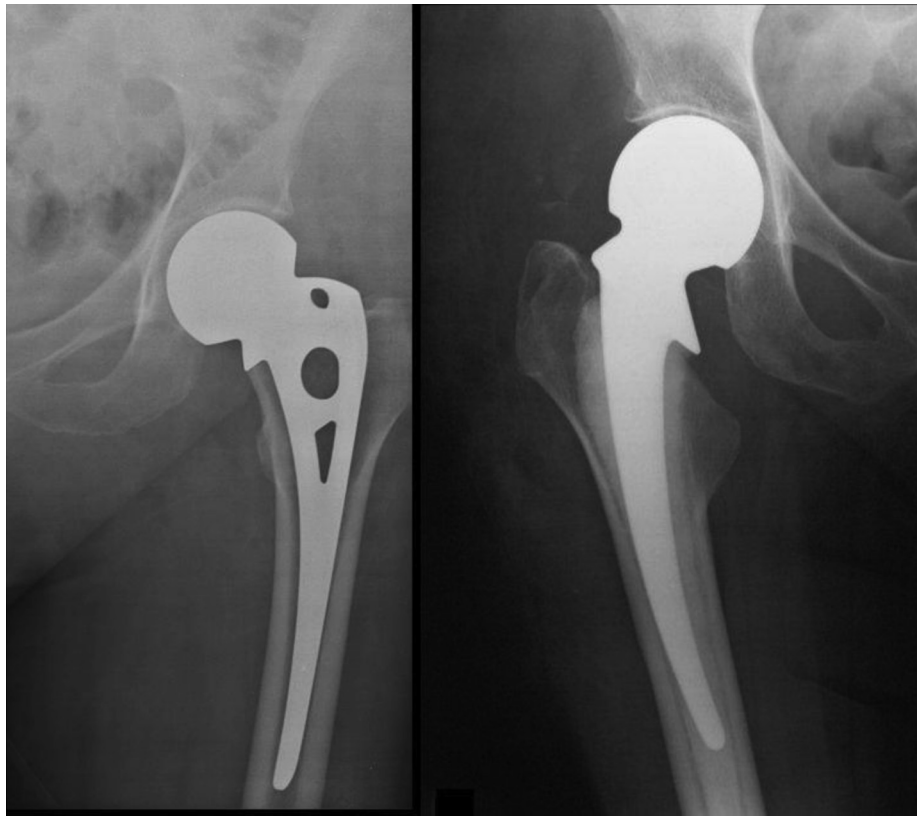


Figure 5 Post-operative clinical radiographs showing an uncemented Austin-Moore Prosthesis (left), and a cemented Thompson Prosthesis (right).

uncemented Austin-Moore hemiarthroplasty (Figure 5). Cementation was not associated with an increase in the complication or mortality rate.

Relevance to current practice

Femoral neck fractures are common injuries in the elderly and form a significant part of any orthopaedic surgeon's practice. Cementation was thought to be associated with an increased complication and/or mortality rate. However, this study does suggest that cementation is a safe technique.

Residual pain levels are also lower in patients receiving a cemented implant coupled with improved mobility. However, Austin-Moore and Thompson implants are less frequently used nowadays, with more contemporary implants, from a variety of manufacturers, taking their place. The recent NICE guidelines¹⁶ advise the use of cemented implants in all hemiarthroplasty cases and advise against the use of Austin-Moore and Thompson implants.

Paper 13 - Impacted fractures of the neck of the femur

Bentley G. *J Bone Joint Surg Br* 1968; **50-B**: 551–61.

Level of evidence: IV (case series).

Aim

To determine the overall prognosis following impacted femoral neck fractures and to assess whether conservative or operative treatment is more appropriate.

Methods

Patients presenting with impacted femoral neck fractures between 1953 and 1965 were included in this case series. The clinical and radiological data were reviewed for all patients. The diagnosis of impacted fracture was made according to specific criteria used for this study. Patients were either treated conservatively or operatively.

Conservative treatment options included bed rest with gentle exercises, use of an anti-rotational shell or light Hamilton-Russell traction. Operative treatment options included the use of Smith-Petersen nails, Moore's pins or a Charnley screw. Patients were followed-up and examined, residual symptoms and functional level determining their outcome score (excellent, good, moderate or poor). The occurrence of 'disimpaction', i.e. further fracture displacement, and avascular necrosis was also recorded.

Results

70 patients with impacted neck of femur fractures were reviewed. 47 patients were managed conservatively. However, within this group, 4 patients who presented late to hospital were excluded. 23 patients were treated operatively. The average age of the study population was 72 years with the majority being female. Patients were followed-up for an average of 2.5 years (6 months to 12 years). 12 patients died during the period of investigation. The 43 patients who were treated conservatively began weight-bearing after 8.5 weeks.

Union of the fracture without further displacement occurred in 36 patients (84%) but gross displacement occurred in the remaining 7 patients (16%). However, there was no association between the conservative treatment options and the risk of displacement. 34 patients had an excellent or good result whilst 9 patients had a moderate or poor result. The other complications of conservative treatment included avascular necrosis (5 patients) and pulmonary embolus (1 patient).

After internal fixation in 23 patients, weight-bearing began approximately 3.5 weeks following surgery. Union occurred in all cases and, in all but one patient, was not associated with gross displacement. 22 (96%) patients had an excellent or good result and 1 patient had a poor result because of a technical error during surgery. At three years, the incidence of avascular necrosis was 14% in the conservative treatment group and 18% in the operative treatment group.

Discussion

Primary internal fixation of impacted femoral neck fractures gave superior results to conservative treatment options. Surgical intervention facilitated earlier mobilization, a lower rate of displacement, increased chance of union and improved clinical results.

Critique

This study had fairly broad aims in following the natural history of a common injury and aimed to identify the optimal treatment strategy. In accordance with much of the research published contemporaneously, this case series lacks statistical analysis or a robust study design. For example, there was no clear intention to match the patient groups. Nonetheless, the findings of the study are valid and suggest that internal fixation confers numerous advantages to the patient.

Key points

Internal fixation of impacted femoral neck fractures allow patients to mobilize sooner and reduces the risk of further displacement.

Relevance to current practice

The findings of this study helped shape the current practice of internal fixation as the standard of care for impacted femoral neck fractures (Figure 6). The aim of treatment is to provide stable fracture fixation in order to allow early mobilization and minimize the risks of immobility.

Paper 14 - The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip

Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM. *J Bone Joint Surg Am* 1995; 77: 1058–64.

Level of evidence: III (retrospective cohort study).

Aim

To introduce and demonstrate that the tip-apex distance is a useful clinical tool for predicting cutout of the screw used for proximal fixation of extra capsular fractures of the hip.



Figure 6 Clinical radiograph illustrating an impacted fracture at the left femoral neck.

Methods

Patients treated for peritrochanteric fractures were included in the study if complete clinical documentation and radiological data was present. Fractures were treated with either a screw and side-plate device or an intramedullary device, all with varying angles at the interface between the screw and plate/nail.

The tip apex-distance (TAD) was used to describe the position of the screw. The TAD is defined as the sum of the distance (millimetres) from the tip of the lag screw to the apex of the femoral head in both AP and lateral radiographs (Figure 7). The femoral head apex is described as the point of intersection between subchondral bone and a line in the centre of and parallel to the femoral neck.

The two end-points of the study were either union of the fracture or cutout of the screw. A variety of statistical techniques were used to determine the significance of the results. An inter-observer and intra-observer assessment was also completed in order to assess the reliability of the TAD calculation.

Results

193 patients (with 198 fractures) were identified for inclusion in the study. The majority of patients were female with an average age of 79 years. Screw and side-plate devices were the most commonly used fixation system. In the study, there were 19 fixation failures with 16 being caused by screw cutout.

The average TAD was 24 mm for the healed fractures in comparison to 38 mm for the cases where the screw cutout

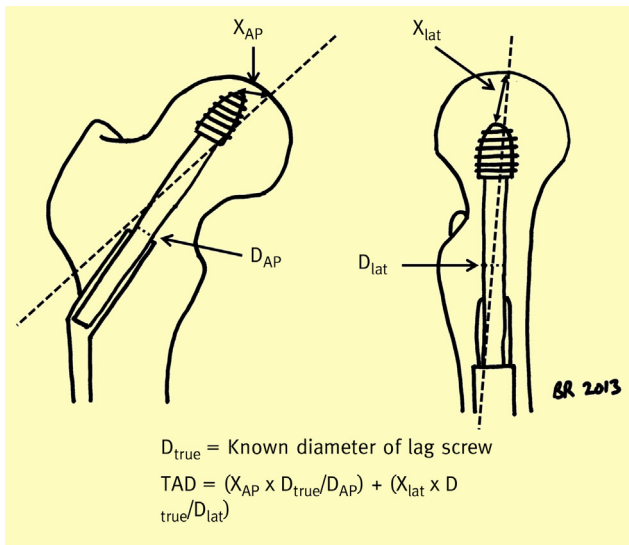


Figure 7 Diagram illustrating how the Tip Apex Distance (TAD) is calculated, which should be <25 mm in order to avoid the risk of cut-out.

($p = 0.0001$). A logistic regression model showed TAD to be the strongest predictor of screw cutout ($p < 0.0001$). Other factors that could be associated with an increased risk of screw cutout included patient age, fracture stability, the quality of fracture reduction and the use of a high-angle side-plate device. It was shown that none of the cases with a TAD of <25 mm led to screw cutout but an increasing TAD was associated with an increasing risk of cutout. The interobserver and intra-observer variability assessment showed acceptable agreement with regards to the TAD calculation.

Discussion

The study supports the convention of placing the screw central and deep in close proximity to the femoral head apex. A TAD of 25 mm or less helps minimize the risk of screw cutout, which is usually a devastating complication. Therefore, it would be prudent to estimate the TAD during surgical fixation in order to guide operative decision-making.

Critique

This study has a clearly stated aim, which has been fulfilled. Although a retrospective study, there are clear inclusion criteria with appropriate use of statistical tools. The follow-up period is relatively short, but this has to be a compromise if one bears in mind the relatively high mortality rate for patients sustaining femoral neck fractures. There were also a number of patients who were excluded from the study due to lack of clinical documentation and/or radiological data. Such exclusion may have caused a selection bias that one could avoid with a prospective study. Despite some methodological issues, this study has provided an easy and reproducible method for determining optimal position of the screw.

Key points

TAD is the strongest predictor of screw cutout. One should aim for a TAD of 25 mm or less. The TAD should be estimated intra-

operatively in order to aid the surgical decision-making process and the guidewire should be re-positioned if necessary.

Relevance to current practice

Proximal femoral fractures are amongst the commonest injuries seen in orthopaedic practice. Sliding hip screw fixation is the optimal treatment for the vast majority of peritrochanteric fractures.¹⁶ Therefore, it is important to site the screw appropriately, with a TAD of 25 mm or less, in order to minimize the risk of screw cutout and provide the patient with a stable fixation.

Paper 15 - Fractures of the femur after hip replacement

Duncan CP, Masri BA. *Instr Course Lect* 1995; **44**: 293–304.

Level of Evidence: IV (case series with expert opinion).

Aim

To describe the epidemiology, pathophysiology and treatment options for periprosthetic fractures of the femur in hip replacement. In addition, the authors introduce a new classification system for periprosthetic fractures of the hip.

Methods

Initially, a literature review was undertaken in order to describe the current epidemiological characteristics, classification systems and treatment options available for periprosthetic femoral fractures. In the later part of the article, patients presenting with periprosthetic fractures of the femur between 1985 and 1994 are reviewed. The fractures are described in terms of a new classification system, developed by the authors, that aims to facilitate the surgical decision-making process.

Results

A total of 75 consecutive patients presenting to Vancouver Hospital and Health Science Centre were reviewed. The majority of patients sustained type B fractures, which were predominantly either B2 or B3. Type A fractures may be treated surgically or conservatively depending on their stability. Type B1 fractures are best treated with open reduction and internal fixation or fixation with bicortical onlay allografts. Type B2 fractures are ideally managed with revision arthroplasty to a long-stem implant. Type B3 fractures benefit from complex reconstruction because these fractures are associated with a loose prosthesis and poor bone stock. Type C fractures are best managed as separate fractures with open reduction and internal fixation.

Discussion

The review describes the current epidemiology of periprosthetic fractures and notes their increasing incidence. The commonly used classification systems and surgical treatments have also been described in detail. The new classification system emphasizes the importance of the prosthesis-bone interface and bone stock in the surgical decision-making process. The appropriate treatment options are described for each fracture subtype, thereby providing a complete guide to treatment.

Critique

This is an excellent and very detailed review article commenting on relevant research. The study highlights the lack of robust research into the field of periprosthetic fractures. In addition, the authors develop their own classification system, which considers the important facets of periprosthetic fractures, e.g. is the implant loose or not? However, there is little discussion of how the classification system was developed or a description of its reliability. Nonetheless, the classification system is valid and easy to use.

Key points

The incidence of periprosthetic fractures of the femur is increasing. When managing patients with such injuries, it is important to consider the implant-bone interface and bone stock in addition to the overall clinical status of the patient. The vast majority of periprosthetic fractures do require surgical fixation in order to facilitate mobilization and avoid the side-effects of recumbency (e.g. pressure ulcers and pneumonia). The new classification system, described in the article, provides therapeutic guidance on the treatment of each fracture subtype.

Relevance to current practice

Periprosthetic fractures are increasingly encountered in clinical practice. It is essential that the nuances of assessment are fully understood so that patients receive the appropriate intervention. The classification system, described by the authors, allows one to consider the critical features of the injury in order to determine the optimal treatment strategy. Failure to do so will, almost certainly, lead to implant failure over time and increase the overall morbidity and mortality rate for this group of patients.

Paper 16 - Should acute scaphoid fractures be fixed? A randomised controlled trial

Dias JJ, Wildin CJ, Bhowal BM, Thompson JR. *J Bone Joint Surg Am* 2005; **87-A**: 2160–68.

Level of evidence: I (prospective randomized clinical trial).

Aim

To determine the rates of union and functional outcome following operative and non-operative treatment of acute undisplaced or minimally displaced scaphoid fractures.

Methods

Prospective randomized clinical trial. Patients were recruited over a three year period. They were randomized by computer into two groups. The operative treatment group underwent early internal fixation of the scaphoid fracture with a Herbert screw and no plaster. The non-operative treatment group were immobilized in a below-elbow plaster (with the thumb free) for 8 weeks. Patients were followed-up at the two, eight, 12, 26 and 52 week mark. At each visit radiographs were taken and patients were clinically assessed for pain, tenderness, swelling, wrist movement, grip strength, symptoms and disability, which were quantified with the Patient Evaluation Measure (PEM). If patients in the non-operative treatment group showed radiographic signs

of non-union at 12 weeks, a CT scan was performed at 16 weeks and surgery was recommended if non-union was confirmed.

Results

In total, 88 patients were recruited to the study (44 in each group). There was no clear difference between the two groups in terms of age, gender, hand dominance, side of injury, mechanism of injury or occupation. At the eight week follow-up visit, wrist movement, grip strength and PEM scores were significantly better in the operative treatment group. The eight-week follow-up visit was also the time when the casts were removed from the patients in the non-operative treatment group. At the 12-week follow-up visit, only grip strength was better in the operative treatment group with no significant difference in the other outcome measures. Minor complications occurred in 13 of the operative treatment group. Ten patients in the non-operative treatment group developed non-union and, as a consequence, their subsequent treatment was altered.

Discussion

Operative treatment led to a degree of early improvement in grip strength and wrist movement but there was no significant difference between the groups beyond the 12-week mark. Non-operative treatment helped avoid the risks of surgery and was not associated with a poorer functional outcome.

In the long-term, there was no difference in outcomes between the two groups. The authors propose an 'aggressive conservative approach' that involves cast treatment (below-elbow Colles type plaster) for undisplaced or minimally displaced scaphoid fractures for 6–8 weeks. If there is a concern about union, a CT scan should be undertaken and operative fixation should be considered if there is a persisting gap at the fracture site.

Critique

This study is a well-constructed computer randomized clinical trial. A power calculation was undertaken and statistics were appropriately used throughout. There are appropriate inclusion and exclusion criteria. The senior surgeon (JJD) was present for all cases, either as operator or supervisor. Therefore, as a 'single centre' study, the results may not be fully reproducible in other centres.

Another potential source of bias is the lack of blinding. It is not clear as to whether the investigators or a separate team assessed the patients at their follow-up visits. If the authors did assess the patients, there is a degree of bias that may have been mitigated by the use of independent assessors. However, blinding is always difficult in studies where the intervention is surgical.

Key points

It is important to establish whether a scaphoid fracture is displaced or undisplaced. If undisplaced, it can be treated in cast for 6–8 weeks. Surgery should only be considered if non-operative cast therapy has failed.

Relevance to current practice

This important study has informed and influenced the management of scaphoid fractures at many institutions both nationally and



Figure 8 Post-operative clinical radiographs showing a headless compression screw that has been used to fix a proximal pole scaphoid fracture.

internationally. It has highlighted that simple below-elbow casts (with the thumb free) can be used rather than the traditional scaphoid cast (thumb immobilized). The study also demonstrates that many undisplaced fractures go on to unite when treated with a cast with no detrimental long-term functional outcomes. However, if fractures failed to unite, there is an appropriate operative intervention that helps attain union (Figure 8).

Conclusions

The articles reviewed above illustrate a range of research methodologies. Articles published more than 50 years ago are typically observational case series or cohort studies. However, the findings of these studies are still valid in today's practice. In contrast, many of the more contemporary studies are methodologically more sound by today's evidence-based standards. It is important that surgeons are able to critically evaluate all research studies, particularly their methodology, in order to assess how they should inform their everyday practice. ♦

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