**Conservative management of displaced paediatric supracondylar fractures: A systematic review**

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**Abstract:**

*Background*: In high-income countries, displaced supracondylar fractures are managed with K-wire fixation. Alternatively, in low-income countries where surgical expertise and resources are limited, these injuries are managed with traction or closed reduction and casting. The aim of our study is to systematically present the published evidence regarding outcomes of conservatively managed displaced supracondylar fractures.

*Methods*: A systematic review of the literature was performed identifying studies evaluating the outcome of displaced supracondylar fractures managed non-operatively.

*Results*: 46 papers examined the outcome of displaced supracondylar fractures managed conservatively. Our results show management by traction is equivalent to percutaneous pinning, whereas outcomes following closed reduction and casting were inconsistent.

*Conclusion*: Closed reduction and casting is inferior to traction and operative intervention in the management of displaced supracondylar fractures. Traction remains a viable option in low income countries (LIC). However, at present there is little data from LICs, limiting the transferability of our conclusions.

**1. Background**

Supracondylar fractures of the distal humerus are the most common injury in children under the age of 7 years, and constitute 18% of the fractures sustained by those under 16 age group [1]. Classification of such injuries is based on a system initially described by Gartland in the 1950’s, summarised in figure 1 [2].Undisplaced Gartland type I fractures are typically managed with cast immobilisation, resulting in good functional outcomes and are not the focus of this study [3, 4].

In the absence of neurovascular injury, displaced closed supracondylar fractures are either managed conservatively or surgically [3]. Surgical treatment options include open reduction and internal fixation or open/closed reduction with percutaneous kirschner wires (k-wire) fixation. The American Association of Orthopaedic Surgeons (AAOS) published guidance in 2011 recommending closed reduction with pin fixation for all patients with displaced injuries [3]. Furthermore, the British Orthopaedic Association Standards for Trauma (BOAST 11) recommend early surgical treatment for these injuries [5]. However, these two guidelines are based on expert opinion and case-series. Options for non-operative management comprise either traction (skin/skeletal) or casting with closed reduction.

Historically, closed reduction and casting provided the mainstay of treatment for displaced injuries. However, rates of Volkmanns ischaemic contracture were high [6]. In the 1920’s Dunlop began treating displaced supracondylar fractures with traction [3]. In doing so, successfully reduced the frequency of serious complications [7]. However, long hospital stays and the inherent associated costs lead to a shift in favour of operative management[8].

In many low and middle income countries (LMICs) surgeons treating supracondylar fractures often lack access to the resources or expertise to manage supracondylar fractures operatively [9]. As a result, many institutes continue to treat displaced supracondylar fractures conservatively [10]. In our institute at Queen Elizabeth Central Hospital, Blantyre, Malawi, straight-arm traction remains the mainstay of treatment for such injuries, with few observed complications.

There is no Level-I evidence available comparing the outcomes of operative versus conservatively managed supracondylar fractures. The aim of this review is to systematically present the published evidence regarding the outcomes of conservatively managed displaced supracondylar fractures.

**2. Methods**

A review of the literature was performed using the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) checklist and algorithm [11]. A search was conducted using Medline, EMBASE and Cochrane computerised literature databases in July 2016. Inclusion and exclusion criteria are displayed in table 1. No year of publication limits were applied and all English language studies were included.

Table 2 shows an example of our data search in Medline, when run in Embase, we retrieved 751 results. The flow diagram of papers included in our review is outlined in figure 2. Following review of abstracts, 35 papers were selected for full text review. Full text review of the remaining papers excluded a further 3; one examining only humeral shaft fractures [12], a second lateral condyle fractures [13], and one contained no conservative intervention [14]. A further 14 articles meeting our inclusion criteria were identified through review of the reference lists. Using Cochrane guidance, a data extraction table was formulated, which was used to collate relevant information from each full text included in the review including assessment of the risk of bias. [15]

Outcome was difficult to assess due to the heterogeneity of the studies, however Flynn’s criteria was the most widely used and comparable outcome measure. All results were tabulated and grouped by method of intervention for ease of comparison. Two authors (DY, SG) performed both review of abstracts and data extraction of the included studies. A total of 46 papers were included for final review (figure 2).

**3.0 Results**

A summary of the 46 papers included in our review are summarised in appendices 1 to 4. Countries income level is based on their World Bank classification as of 1st January 2017 [16].

**3.1 Closed reduction and casting**

28 studies examined outcome data of closed reduction and casting for displaced supracondylar fractures [17–44]. This included any method of immobilisation whereby plaster of paris was applied to the injured arm, set under any degree of flexion. Closed reduction was performed and where specified, manipulation of the displaced injury was performed under general anaesthetic, local block, or sedation.

The most commonly used outcome measure was Flynn’s criteria which evaluates both cosmetic and functional outcomes. The remainder used other functional criteria, radiographic evaluation or re-operation rate following failure of plaster cast immobilisation. Due to the heterogeneity of the outcomes amongst the studies in question, we did not to compare them quantitatively.

Four studies found casting to be viable first line management for displaced supracondylar fractures [25, 27, 29, 44]. However all acknowledge a proportion would require delayed pinning in the event reduction was lost, this was not found to affect long term outcomes. These papers did not differentiate between Gartland types II and II.

Overall, inconsistent outcomes following closed reduction and casting makes it challenging to draw broad conclusions from the data in our review. Although a number of papers continue to advocate the method, especially in a low-income setting [44] others suggest operative fixation provides superior outcomes [33, 38]. In two papers, when a distinction was drawn between Gartland type II and III injuries, casting was found to provide unsatisfactory outcome in type III, but good results in type II [33, 38].

**3.2 Traction**

Our review of the literature found 24 studies presenting outcome data following traction as management of displaced supracondylar fracture [8, 18, 22, 29–31, 37, 40, 42, 43, 45–60]. Outcomes of overhead skeletal traction straight-arm lateral traction, skin traction, side arm traction, and brace with traction, were all examined and results displayed in appendices 1, 2 and 3.

When compared directly to operative intervention for comparison, traction resulted in equivalent outcomes [18, 29, 37, 42, 43, 56, 57]. Sutton et al. presented a retrospective case series (n=65) directly comparing traction with percutaneous pinning [56]. Using Flynn’s criteria as their principle outcome measure, the paper concludes no statistical difference when comparing the two methods [56]. However the paper did not state the grading of Gartland fracture between the two treatment groups. Where cost of treatment was assessed, traction was more expensive than operative intervention, hence two papers concluding percutaneous pinning to be their preferred option [8, 56].

A total of sixteen papers studied the outcomes of skeletal traction, of these, eight used Flynn’s criteria as their primary outcome measure. Eight studies examined straight arm traction, two of which used Finn’s criteria. There was no statistically significant difference when compared directly. One paper did not specify the method of traction used [42].

One paper concluded traction to have superior outcomes to casting, pinning and ORIF [22].

All eleven studies examining traction without operative intervention found it to provide excellent outcomes in severely displaced or swollen injuries. No patients managed with traction required subsequent operative intervention [47–52, 54, 55, 58-60].

**4.0 Conclusion**

Our review has shown that current evidence for the management of displaced supracondylar fractures is inconclusive. It appears that closed reduction and casting may be utilised in the first instance with positive results, with the option of percutaneous pinning in the event of failed reduction. Whereas outcomes following traction appear to be equivalent to that of percutaneous pinning, although this conclusion is drawn from a limited number of studies. Despite this, the trend of managing all displaced injuries operatively within high-income setting remains unchallenged.

Where resources allow, operative intervention is now regarded as the gold standard management for Gartland II and III injuries [3]. The British Orthopaedic Association Standards for Trauma state that displaced supracondylar fractures “*…require early surgical treatment; ideally on the day of admission… surgical stabilisation should be with bicortical wire fixation*.” [5] However, these are guidelines and cannot be translated to healthcare provision in resource-limited settings. The results of this review suggest that where surgical intervention is unavailable, such as in Malawi, traction remains the preferred management.

Anatomical reduction is required for percutaneous pinning to succeed [3]. Hence attempting the procedure without the aid of intraoperative fluroscopy would be hazardous, limiting its use to environments where such resources are available. Complications such as ulnar nerve injury, pin migration and pin tract infection are reported in the literature with rates between 1.8% and 4.7% [61–63]. O’Hara et al. report rates of cubitus varus deformity of up to 32% when protocol and x-ray is not strictly followed with K-wire insertion [34]. There is therefore a trade-off between conservative management, where possible mild mal-union would result in normal function but a potential cosmetic issue, and operative intervention where the complications intra and post-operative complications can be significantly worse.

It is not only the access to surgical skills and equipment that limit the use of operative intervention in LIC’s. Access to anaesthesia is a problem throughout sub-Saharan Africa, where facilities to deliver safe anaesthesia to a child have been reported to be as low as 13% [62]. This additional risk of operative intervention provides us with further insight as to why traction remains the preferred method of treatment in many countries.

There were no cases of Volkmann’s ischaemic contracture in the papers included within our review. Loss of reduction was the only indication reported in the four studies recommending initial closed reduction with subsequent operative intervention.

The disparity between outcome measures used gives our data limited transferability. Although Flynns criteria is used the most frequently, outcome measures in the literature are wide ranging [63]. Flynn provides a method of analysis whereby results can be easily compared using change in carrying angle and range of motion. However, this clinical outcome is not patient reported and can be prone to measurement bias. Changes in carrying angle, associated with a poorer score of Flynn’s criteria, may not always equate to a worse functional outcome. There is a need for a validated functional outcome measure in children, encompassing patient reported outcome measures.

One limitation of many papers in our review is the lack of transparency when allocating patients to treatment groups. It was frequently unclear how patients had been selected to be managed conservatively or operatively. Indeed, in retrospective case series, this cannot accurately be measured. Recruitment bias may well therefore have confounded several authors conclusions.

Cubitus varus is widely considered a cosmetic problem, usually only evident when standing in the anatomical position [64]. Review of patients with residual cubitus varus following supracondylar fracture found no functional deficit and can be corrected via planned geometric osteotomy at a later date if required [65]. The incidence and long-term consequences of cubitus varus deformity in low-income countries have not been investigated in the current literature.

Traction is well documented to result in a longer hospital stay than operative intervention. In our review, a total of thirteen papers specify the length of hospital stay when managed by traction. If not otherwise stated, the total duration of traction was taken as the length of hospital stay. Duration of inpatient stay ranged from 11 – 22 days with a median of 19 days. Two papers used length of stay as contributing factors of their cost analysis, both concluding traction was considerably more expensive than pinning [8, 56]. When considering duration of stay, theatre fees, anaesthetic fees, recovery room fees and radiography fees Sutton et al. and Piretto et al. calculated traction was more expensive by 142% and 179% respectively. However, both papers were based in high income countries, where costs of both equipment and service provision make calculations non-transferable to less economically developed nations.

The use of traction for Gartland types II and III supracondylar fractures provides a safe and effective alternative to percutaneous wire fixation in the resource poor setting. In countries where few specialist centres are managing increasingly high volume of trauma, the benefit of such surgical intervention remains to be proven. With the correct expertise, traction can be safely applied in a local setting, avoiding the need for long-distance transfer and associated financial cost. All papers in our review analysing long term outcome measures of traction alone, support this premise.

Currently there is no level one evidence comparing percutaneous pin fixation with traction for displaced supracondylar fractures of the distal humerus in children. Drawing on conclusions from the studies in this review, there is a suggestion that these two management options remain in clinical equipoise. Our review also highlights the lack of data from LICs on this topic, which would improve the transferability of our conclusions.

**Figure Legends:**

Figure 1: Lateral views of supracondylar fractures according to the Gartland Classification (i) Type 1 (undisplaced) (ii) Type 2 and (iii) Type 3

Figure 2: Flow diagram outlining studies included for review

Table 1: An outline of inclusion and exclusion criteria used in our review

|  |  |
| --- | --- |
| Inclusion Criteria | Exclusion Criteria  |
| 1. Paper written in English
 | 1. Undisplaced supracondylar fractures included in study |
| 1. Level I, II, III or IV study design by *Journal of Bone and Joint Surgery* criteria
 |  |
| 1. Series reporting on supracondylar fractures of Gartland types II or III (displaced)
 |  |
| 1. Conservative (non-operative) management in one or all arms of the study
 |  |
| 1. Assessment of outcome (functional, anatomical or radiological)
 |  |
| 1. All patients in the study were <18 years old
 |  |

|  |  |  |
| --- | --- | --- |
| No. | Search Term | Number of Results |
| 1 | (supracondylar adj3 fractur\*).ti,ab. | 2095 |
| 2 | (supracondylar adj3 (break\* or broken)).ti,ab. | 3 |
| 3 | 1 or 2 | 2095 |
| 4 | Conservative Treatment/ | 317 |
| 5 | (conservativ\* adj3 (manag\* or treat\* or therap\*)).ti,ab. | 67170 |
| 6 | nonsurgical\*.ti,ab. | 13850 |
| 7 | non surgical\*.ti,ab. | 10120 |
| 8 | closed reduction\*.ti,ab. | 4547 |
| 9 | plaster external traction.ti,ab. | 1 |
| 10 | Watchful Waiting/ | 2480 |
| 11 | (watchful\* adj3 wait\*).ti,ab. | 2163 |
| 12 | (watchful\* adj3 expectan\*).ti,ab. | 37 |
| 13 | traction.ti,ab. | 16040 |
| 14 | (conservativ\* adj3 (manner\* or method\* or measur\*)).ti,ab. | 5348 |
| 15 | nonoperativ\*.ti,ab. | 10399 |
| 16 | non operativ\*.ti,ab. | 4713 |
| 17 | ((cast\* or plaster\* or sling\*) adj3 (immobolis\* or immobiliz\*)).ti,ab. | 1849 |
| 18 | 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 | 129449 |
| 19 | 3 and 18 | 578 |

Table 2: Example of search criteria used in our review in Medline

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