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Fractures of the Clavicle: An Overview

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Abstract: Fractures of the clavicle are a common injury and most often occur in younger individuals. For the most part, they have been historically treated conservatively with acceptable results. However, over recent years, more and more research is showing that operative treatment may decrease the rates of fracture complications and increase functional outcomes. This article first describes the classification of clavicle fractures and then reviews the literature over the past decades to form a conclusion regarding the appropriate management.

A thorough literature review was performed on assessment of fractures of the clavicle, their classification and the outcomes following conservative treatment. Further literature was gathered regarding the surgical treatment of these fractures, including the methods of fixation and the surgical approaches used. Both conservative and surgical treatments were then compared and contrasted.

The majority of recent data suggests that operative treatment may be more appropriate as it improves functional outcome and reduces the risk of complications such as non-union. This is particularly evident in mid shaft fractures, although more high grade evidence is needed to fully recommend this, especially regarding certain fractures of the medial and lateral clavicle.

Keywords: Clavicle fracture, internal fixation, locking plate, Rockwood pin.

INTRODUCTION

Fractures of the clavicle are common injuries accounting for between 2.6 and 4% of adult fractures and 35% of injuries to the shoulder girdle [1-3]. Early reports of clavicle fractures date back to Hippocrates [4], who noted that "*when a fractured clavicle is fairly broken across it is more easily treated, but when broken obliquely it is more difficult to manage*". Clavicular fractures are most common in younger patients with incidence greatest in the second and third decades. The prevalence of fractures to the clavicle has been seen to decrease with every decade, after a patient is 20 years of age. However, the ratio of female to male increases with age. The aetiology of clavicle injuries in young adults and children is most commonly an RTA, sports injury and, to a lesser extent, a fall. However, falls represent their most frequent cause among the elderly [3]. Clavicle injuries can be grossly divided into three distinct anatomical sites; the medial clavicle, shaft and lateral end. Mid-shaft clavicle [1, 3] fractures are most common, with an incidence of up to 82% of all clavicle fractures. Medial and lateral end fractures account for approximately 18 and 2% respectively [3]. The location and pattern of injury are of considerable importance when formulating a management plan.

There has been an increase in treatment options available andin the frequency with which clavicle fractures are treated operatively. A number of technical challenges exist for the operating surgeon and clinical results for a range of methods of treatment have been variable. Here we summarise the assessment and management of fractures of the clavicle, providing an overview of the clinical results of a range of treatment options.

CLASSIFICATION

A number of classification systems have been described for the classification of clavicle fractures [1, 5-7]. Allman [5] divided clavicle fractures by anatomical site into 3 groups; group 1 being fractures to the middle third, group 2 being fractures distal to the coraco-clavicular ligament, and Group 3 relating to fractures of the proximal third of the clavicle [5]. Neer [6] went further and subdivided lateral third fractures into three groups; undisplaced, displaced, and intra-articular. The displaced types were then divided into 2a or 2b, depending on the presence of injury to the coraco-clavicular (CC) ligaments [6]. Thus a type 2a injury represents a fracture medial to both conoid and trapzezoid elements of the CC ligaments, with the shaft displacing superior relative to the lateral end. A type 2b injury represents a fracture of the lateral end of the clavicle, with disruption of the conoid portion of the CC ligament [6]. Robinson [1] was the first to describe clavicle fractures in relation to their displacement and degree of comminution, *via* the Edinburgh classification. He then used his parameters to predict the risk of non-union, in such fractures, with good affect [7]. The Edinburgh classification system has been shown to provide more reliable prognostic information in

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middle third fractures, in comparison to other classification systems.

ASSESSMENT

After detailing the history of the presenting complaint, including the mechanism of injury, a thorough clinical examination should be performed. The examination should include both shoulders and the arm, to exclude any vascular or brachial plexus injury. Differing limb blood pressures may be present if there is a vascular injury and, if clinically suspected, a duplex or angiogram should be arranged. Upon inspection, it is important to note any skin tenting or punctures, as well as the presence of ecchymosis, around the fracture site. The fracture may have a striking deformity, particularly if it is a displaced mid-shaft fracture, as the weight of the shoulder/arm pulls the lateral fragment caudally, whilst the sternocleidomastoid muscle pulls the medial end in a cephalad direction. An assessment of the neurovascular status of the affected limb is mandatory. Patients should also have a plain antero-posterior (AP) X-ray performed in the emergency department. In fractures of the medial third, a plain x ray may be inconclusive and it is not difficult to confuse a fracture with sterno-clavicular dislocation. Moreover, AP radiographs may provide the viewing clinician with little or no information regarding the degree of posterior displacement of the clavicle in medial third injuries, which may affect the mediastinal or apical structures. Other projections of the clavicle may be performed after liaising with a radiographer, such an apical oblique view of the clavicle with the patient standing at 45 degrees toward the beam and the beam angled 20-30 degrees cephalad. In addition, computed tomography (CT) of the clavicle with 3D reconstruction has been shown to be a useful diagnostic aid [8].

TREATMENT

The majority of clavicle fractures are treated non-operatively with good outcomes [9-12]. Measures such as an arm sling, analgesia and, in the case of mid shaft fractures, a figure of eight bandage across the shoulders, often provide ample treatment. Early comparisons of conservative and operative measures were in favour of conservative treatment. Neer [11], in a retrospective review of 18 cases of clavicle non-union, and Rowe [12] both demonstrated an increased rate of non-union following open reduction and internal fixation of clavicular shaft fractures. More recently, there has been a trend towards an increased rate of operative intervention, particularly in mid-shaft fractures. A number of authors have demonstrated lower rates of complications, such as pain, non-union and instability. Furthermore, improved functional outcomes have been demonstrated in patients having operative management compared with conservative measures[10, 13]

MID SHAFT CLAVICULAR FRACTURES

Undisplaced mid-shaft fractures are generally managed non-operatively. Displaced or angulated fractures, which are closed injuries, are also usually managed by conservative means. The use of a simple arm sling and the figure of eight bandage are the most widely reported methods of conservative management for a mid-shaft fracture of the clavicle. In 1987 Andersen et alreported less discomfort and a trend towards fewer complications with a sling and similar clinical and functional results with either a sling or a figure of 8 bandage [14]. The Cochrane review in 2009 has recommended that further research is warranted in this area to form an appropriate conclusion [15].

Until recent years, both slings and figure of 8 bandages were used as accepted methods of treatment for displaced fractures. Altimimi et al reported the results of a multicentre prospective randomized trial in 2009, comparing non-operative treatment and internal fixation in 132 patients with displaced midshaft fractures of the clavicle. They demonstrated improved functional scores, lower pain scores, shorter time to union and greater patient satisfaction at all time points up to one year after surgical fixation in the group treated with a plate [13]. Despite this, the operative group had a complication rate of 34% and a reoperation rate of 18%. Complications included local irritation, prominence of hardware, plate failure and wound infection. The reoperations were predominantly for the removal of the hardware. It is widely accepted that, due to complication rates with primary operative treatment and the satisfactory results of the operative treatment of nonunion or malunion, many displaced fractures should be treated conservatively with care taken not to over treat [16]. Many clinicians reserve operative treatment for open injuries, or those with significant skin tenting, and fractures in which the initial shortening is >20mm; a characteristic associated with high nonunion rates if treated conservatively [17]. More research is needed to gather level I and II data, to produce guidelines on whether fixation is suitable for all displaced mid-shaft fractures.

A recent meta-analysis [18] of randomized trials, comparing operative and non-operative treatment, has supported previous data demonstrating significantly lower rates of non-union and mal-union, with an earlier return of function, in midshaft fractures treated with internal fixation. However, the long-term functional benefits of internal fixation remain unclear.

A range of implants are available on the market for internal fixation of diaphyseal fractures, broadly divided into plate/ screw configurations and intramedullary devices. The use of dynamic compression plates (DCP) [19], locking plates (LP) [20] and reconstruction plates [21] have all been reported in the literature. Reconstruction plates have largely fallen out of favour due to their weakness and potential to deform at the site of the fracture leading to mal-union. The use of locking plate devices provides stability of the fracture, pain relief and facilitates early mobilization of the shoulder [22].

A number of authors have examined the comparative biomechanical properties of plates and intramedullary devices for diaphyseal clavicle fractures. Golish *et al.* demonstrated that plate fixation provides a superior construct, demonstrating decreased displacement at fixed loads, as well as greater loads at fixed levels of displacement during a wider range of movements. This may be of benefit in early/ accelerated rehabilitation protocols [23]. In the presence of comminution, which is usually inferior, locking plates are advantageous as their position on the superior aspect of the clavicle bestows greater stability than an intramedullary device [24]. Surgeons must be aware, however, of a greater risk of injury to the underlying neurovascular structures from drilling and manipulation of the fracture. Alternative approaches have been reported with an antero-inferior approach associated with low nonunion and infection rates and an excellent return to function [25]. Testing of this biomechanically, against a superior position, has shown that a superior plate position may provide a more secure fixation of the fracture. Pre-contoured locking plates may be less prominent after healing and may lead to less incidence of hardware removal [20]. The complications associated with plate fixation are; infection, non-union, mal-union, further surgery, scarring, re-fracture after plate removal and intra-operative vascular injury [26, 27]. Intra-medullary fixation has been shown to result in fewer complications, as it preserves the soft tissue envelope and periosteum, as well as being cosmetically more pleasing [28].

Because of the sigmoid shape of the clavicle, intra-medullary fixation of fractures has traditionally been difficult. Static locking is not available on current devices. The implant has to be small enough to negotiate the narrow intra-medullary canal and the sigmoid bend in the clavicle, whilst still being strong enough to cope with the forces across the fracture until bone union [29]. There are a wider range of devices for intra-medullary fixation of the clavicle including; Knowles pins [30], Rockwood pins [31], Hagie pins [10] or titanium elastic nails [28]. Two principal methods for device insertion exist: antegrade *via* an antero-medial entry point, and retrograde *via* a postero-lateral entry point. Clinical results of intra-medullary fixation have been varied [10, 32]. However, the potential benefits are well known such as minimal tissue dissection and soft tissue stripping, leading to less disruption to the periosteal blood supply. Intra-medullary fixation also avoids the development of stress risers, caused by the removal of multiple screws during plate removal, thereby minimizing the likelihood of a re-fracture. However, complications such as hardware breaks, nerve injury and skin breakdown have been reported [33, 34] as well as hardware migration and injury to infraclavicular structures [35]. In the absence of static locking, there may be shortening of the clavicle over time, a problem that is more likely in comminuted fractures. This complication is particularly associated with unthreaded devices such as Kirschner wires or Titanium nails [33, 36], but it has also been reported in threaded Kirschner wires and a Hagie pin [35].

Clinical results with intramedullary fixation are variable and many surgeons prefer plate fixation for primary operative treatment of clavicle fractures or non-unions. It is worth noting, however, that intramedullary fixation is also useful in those patients with multiple injuries or additional shoulder pathologies, due to its minimally invasive approach [37]. As an alternative to internal fixation, external fixators may be also used in certain circumstances, although these are only recommended for use in open fractures or in the case of a septic non-union [38].

LATERAL END FRACTURES

Undisplaced fractures of the lateral end of the clavicle (Neer type 1, Edinburgh type 3A) are generally treated conservatively as they have an intact periostial sleeve and are relatively stable, due to the intact conoid and trapezoid CC ligaments [11]. Good results have been reported with conservative measures [39] using analgesia and an arm sling. Occasionally these fractures may have an intra-articular component, which can cause late pain and/or stiffness. If problematic, the small distal fragment can be removed surgically with favourable outcomes [11, 39].

Displaced lateral clavicle fractures are often treated operatively [6, 39] with conservative measures being associated with high rates of non-union [1, 5, 6, 39]. A systematic review of lateral clavicle fractures, published in 2010, reported a 33.3% non-union rate in conservatively managed injuries and a 6% nonunion rate in those treated operatively [40]. Non-operative treatment is generally used in those patients who are low demand, elderly or frail [41]. An increase in the incidence of lateral clavicle fractures is seen in elderly patients and conservative management in this age-group is not associated with significant functional loss in the presence of a non-union [42]. For the majority of younger patients with these fractures, operative treatment is more appropriate. A range of techniques are described for fixation of these injuries including; plating (hook-plate, locking T plates) [43, 44], coraco-clavicular screw [45], Kirschner wires [46] and Knowles pins [47].

In the case of a standard distal clavicle plate, three screws (a minimum of two) should be placed in the distal fragment to provide sufficient stability [48]. The relatively recent introduction of contoured plates (such as the locking T plate) allows more screws to be placed in the distal fragment, which may improve stability [49]. Clinicial results with pre-contoured plating systems have been positive, with a number of authors reporting good functional outcomes and few complications [43, 50, 51]. Martetschlager *et al.* [43] treated 30 patients with a locking T plate and supplementary PDS circlage suturing, achieving union within 10 weeks and good or excellent functional outcomes with a return to premorbid levels of activity in all cases. These results were supported in a recent report by Kang et al. [50] in a group of 10 patients with non-unions of the distal lend of the clavicle. Mean time to union was 14 weeks, with all patients demonstrating good or excellent functional scores at final follow up of 24 months.

The hook-plate was specifically engineered for acromio-clavicular injuries, such as dislocations, as well as to provide operative treatment for fractures with a small distal fragment where other plating techniques would be inappropriate [52]. Good *et al.* prospectively reviewed 36 cases of distal clavicle fracture that underwent hook plate fixation as a primary procedure. Mean time to union was 3 months with a union rate of 95% [44]. In a recent study by Tiren at al, 28 patients were managed primarily with a hook plate, achieving union in all but 1 case (96%). At a mean follow up time of 5.4 years, the mean Constant functional score was 97 with mean DASH scores 3.5. The authors noted a 32% incidence of subacromial impingement and a 25% rate of subacromial osteolysis. In all cases, symptoms resolved following removal of the plate allows early mobilization and good subjective and objective functional outcome. The presence of subacromial impingement, or osteolysis, may be due to anatomical variations in the acromion and lateral clavicle.

Problems can be avoided by bending the plate slightly to fit the patient [53].

Coraco-clavicular screws have been described, as far back as 1941 by Bosworth, as a method of treatment for acromio-clavicular separation [54]. This type of fixation is relatively widely used, with a number of studies demonstrating encouraging results [55]. It is worth noting that this procedure can be technically demanding because of the small area of coracoid that is available for screw insertion, which is associated with a higher rate of fixation failure [16]. Kirschner wiring has been used in the past but, as with mid-clavicular fractures, there are problems with pin migration [56] as well as non-union and infection [57].

Surgical techniques, involving sutures and or ligament grafts, have been used either alone or alongside primary fixation to good affect [58]. This is implemented by looping sutures around the coracoid process and the distal clavicle, or by drilling holes within the clavicle. The 'tightrope technique,' which involves two EndoButtons in the clavicle and coracoid, and a loop of suture material through these, has been described as also demonstrating good early results for use in both fractures and dislocations [51, 59]. This also has the added advantage of there being no need for implant removal.

Lateral end fractures, involving the articular surface (Neer 3, Edinburgh 3A2 and 3B2), are relatively rare and make up around 3.3% of clavicular fractures [1]. These are normally treated similarly to non-articular lateral fractures, depending on the amount of displacement [16].

MEDIAL END FRACTURES

Fractures of the medial clavicle (Edinburgh 1) are rare and account for approximately 2% of all clavicle fractures. Despite their rarity, these fractures can be dangerous due to damage to the neurovascular structures situated posteriorly [8]. It is important to ascertain, both clinically and by radiological imaging, if the injury is an acute fracture or an epiphseal separation, which can remain open until 30 years of age. Approximately 80% of the length of the adult clavicle comes from the medial growth plate [60]. The stability of this type of fracture is maintained by the costo-clavicular ligaments. If these are affected, the fracture is more likely to be unstable [5]. Because of the close proximity of the mediastinal structures, formal fixation is considered only in the event of marked displacement of the clavicle, with a risk to underlying structures [8, 61].

CONCLUSION AND RECOMMENDATIONS

Clavicular fractures are common and they predominantly affect the younger age group. The decision on treatment should be made in conjunction with the patient, taking into account their age, comorbidities, fracture classification, soft tissue injury and individual surgeon and patient preferences. Although traditionally these fractures have been treated non-operatively with acceptable results, there is now good evidence which demonstrates improved functional outcome with internal fixation. Furthermore, a reduced risk of non-union and symptomatic malunion is also seen in cases undergoing operative treatment, particularly for fractures of the diaphysis. Further work is required in the form of prospective comparative data, examining methods for fixation and conservative measures in both medial and lateral end fractures.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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