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Management of Extra-articular Scapular Fractures: A Narrative Review and Proposal of a Treatment Algorithm

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The management of scapular fractures can be either conservative or operative, but it is still unclear how to choose the treatment option. Scapular fractures can be classified anatomically into four types: scapular spine, scapular body, and scapular neck where the treatment is conservative most of the time except for certain indications that are specific to each one, and inferior angle of the scapula where the operative treatment yields the best results but conservative treatment can be contemplated in some cases.

Keywords: *Scapular fracture, Inferior angle of scapula, Scapular neck, Body of scapula, Scapular spine*

Scapula fracture epidemiology is undergoing change. Scapula fractures have traditionally been regarded as high-energy fractures that serve as indicators of serious comorbid injuries.[1] According to the U.S. National Trauma Data Bank, the rate of this specific injury doubled from 1% to 2.2% within a single decade, suggesting that it may be on the rise.[2] The greater use of computed tomography to evaluate trauma patients, which can result in a higher detection of trauma,[3] may help to explain this in part.

Due to the scapula's particular biological and mechanical milieu, fracture stability and the likelihood of displacement are affected even in the first few days following injury.[4] In fact, scapular extra-articular fractures can be managed either operatively or conservatively depending on the injury, the anatomy, the surgeon, and the demand of the patient.[5-7] However, there are no randomized controlled trials or prospective studies that can offer an accurate option for the treatment of these fractures.[8] There are some studies that have compared operative and nonoperative treatment,[9,10] but the sample sizes of these studies were too small to draw any meaningful conclusions and none of them were specific for extra-articular fractures. Furthermore, the heterogeneity in classification systems and outcome assessment makes it challenging to compile the available data to promote a better understanding regarding the management of these injuries. This narrative review will shed the light on available evidence regarding the management of extra-articular scapular fractures and propose a treatment algorithm that may be able to solve this controversy.

MANAGEMENT IN GENERAL AND INDICATIONS

Usually the type of treatment depends on the fracture (whether it meets the criteria for surgical repair or not), the patient (whether he agrees to undergo the surgery after hearing about both the conservative and surgical management), and the doctor (the experience of the doctor).[11] Conservative management consists of the use of a sling for approximatively 3 weeks waiting for consolidation and pain relief[12] and physiotherapy as soon as 1 week after the accident.[13,14] Schofer et al.[11] found that a better shoulder function was found in patients who had undergone less than 30 sessions in physiotherapy. However, these patients

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did not need more than 30 sessions because they achieved good results before that, whereas patients who needed more than 30 sessions did not recover their function well and they needed extra sessions that were not that helpful in reaching a pre-injury level of shoulder function.[11]

During healing, pseudo-paralysis of the shoulder may be reported alongside a progressive deformity of the fracture especially in the early phase after the injury.[4,5] This deformity may be caused by gravitational stress alongside the instability of the fracture itself, which may ultimately lead to surgery.[15] Although conservative treatment has always been the preferred approach for scapula fractures, operative treatment is considered as better treatment in some fractures depending on many factors: medial displacement of the glenoid neck fragment by more than 1 cm and/or anterior angulation equal to or greater than 40°,[16] 25° to 45° angulation on a lateral radiograph, glenopolar angle (GPA) < 20°, displaced double lesions of the superior shoulder suspensory complex (SSSC), which includes the glenoid process, the coracoid process, the coracoclavicular (CA) ligaments, the distal clavicle, the acromioclavicular joint, and the acromion,[12,17] medial displacement of the lateral border > 25 mm, and intra-articular step of 3 or 5 mm.[4] Although medialization of the glenoid is frequently cited as a surgical reason, caution should be exercised when using this idea. The lateral displacement of the scapula's lateral border induced by the linked teres muscles frequently has the appearance of medialization. True medialization of the glenoid is substantially less common than assumed when measured from the midline and compared to the opposing shoulder.[18] Likewise, caution must be used while calculating the GPA. It was demonstrated that the GPA decreased when the scapula's rotation shifted away from the scapula in the coronal position (GPA 0°), both in internal and exterior rotation. Rotational displacement could therefore result in an inaccurate treatment indication due to a mistake in the measurement of GPA. It is advised that, if possible, GPA measurements be performed with the scapula in a neutral posture at 0° and in neutral rotation.[19]

Additional indications may appear in more unusual circumstances such as when displacement affects the function of the scapulothoracic joint rather than the glenohumeral joint. A previously described example of this is angular deformity greater than 45°.[4] For the same reason, severe chest wall deformity due to underlying rib fractures may fall into this group and serve as a recommendation for rib fixation.[4] Other more exceptional cases include the displacement of the scapula's angle so that it becomes intra-thoracic[20] and the displacement of the scapula's blade segments so that they pierce the subscapularis and protrude into the chest wall, causing discomfort and mobility restrictions.[21] Furthermore, if displaced, isolated fractures of the coracoid process or acromion may be considered a fixation indication.[22]

Conceptually, extra-articular fractures that should benefit from fixation are those that are sufficiently displaced so that shoulder function would be predicted to be harmed by nonsurgical therapy. Because of this, each case should be evaluated on its own. Even if the criteria are met, this establishes a relative indication for surgery, which should be discussed with a surgeon experienced in the surgical management of scapular fractures in light of the particular patient and injury characteristics.[4]

CLASSIFICATION

The first classification of scapular fractures was made by Jean-Louis Petit and it identified fractures of the scapula that affected the body, neck, and processes.[4] This is a very helpful descriptive classification, so one considers it to be at the very base of the much more recent AO Foundation/Orthopaedic Trauma Association (AO/OTA) classification.[23] This divides scapula fractures into intra-articular fractures affecting the glenoid fossa (14C), and extra-articular injuries affecting the processes (14A) and the body (14B) (Fig. 1).[4] In our article, we divided the fractures into fractures of the acromion (scapular spine), scapular neck

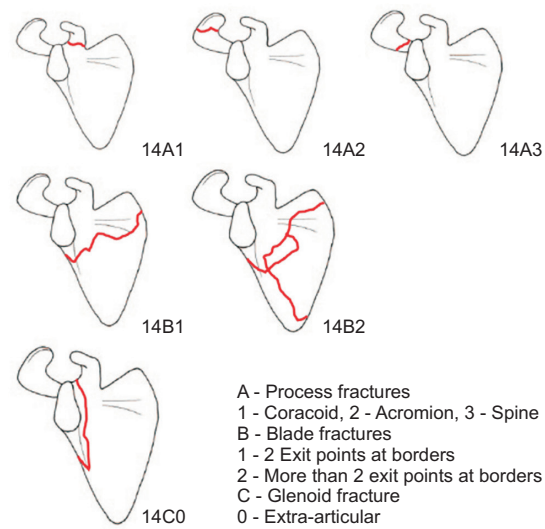

Fig. 1. Arbeitsgemeinschaft für Osteosynthesefragen (AO) extra-articular fractures of the scapula as they are classified in the AO Foundation/Orthopaedic Trauma Association (AO/OTA) classification system. Adapted from Lim. EFORT Open Rev. 2021;6(6):518-25.[4]

(extra-articular glenoid), scapular body, and inferior angle of scapular. Similar classifications were used by other articles;[4,8] however, we added the inferior angle of scapula since its management differs from the scapular body fractures and we focused only on the extra-articular fractures of the scapula. Furthermore, scapula fractures in pediatric patients were also considered.

FRACTURES OF THE ACROMION

The sudden increase in reverse shoulder arthroplasty procedures has brought attention to a rare but serious complication, fracture of the scapular spine, which arthroplasty surgeons experience more frequently than trauma surgeons.[4] This most frequently happens near the spinoglenoid junction or at the base of the acromion.[4] After a reverse shoulder arthroplasty, treating scapular spine and acromial fractures can be difficult since different forms of treatment have variable results.[4]

The recommendations are frequently based on a small number of instances, and there is no gold standard for treating these kinds of fractures.[24] These recommendations state that conservative care in individuals with minimally or nondisplaced fractures have been encouraging.[24] Nevertheless, complications develop in patients with conservatively treated fractures such as symptomatic nonunion,[25-28] persistent pain, reduced function, rotator cuff tears secondary to a displaced fracture and reduction of the subacromial space, acromioclavicular joint separation, humeral head subluxation, and brachial plexus injury.[13,27,29,30]

In situations of displaced fractures, prolonged symptomatic nonunions, or additional injuries to the SSSC, almost all authors advise operational intervention.[13,27,31,32] Acromion open fractures require immediate surgery, not just to seal the soft tissue but also to do additional open reduction and internal fixation.[33,34] Additionally, Baur et al. suggested operating on all displaced fractures[35] where anatomic restoration may stop muscle dysfunction and scapular dyskinesia, especially in fractures with reduced subacromial space.[36]

As for the surgical technique, most authors indicate a preference for surgical methods that involve plate fixation in addition to operative treatment.[24] However, peripheral lateral or anterior fractures are more challenging to repair due to anatomical issues.[24] It is advised to use tension band wiring for these fractures because sufficient compression is not possible with K-wire fixation and plating.[24,37] Additionally, due to plate thickness and local irritation, implant removal is described more frequently in plating than in tension band wiring.[24]

Therefore, conservative management is the mainstay of treatment in acromion fractures unless it is an open fracture, the fracture is displaced, there is a prolonged symptomatic nonunion, or the SSSC is injured. In general, plating is recommended except in peripheral lateral/anterior fractures where tension band wiring has better outcomes.

SCAPULAR BODY FRACTURES

Of all isolated scapular body fractures, 99% are treated conservatively, achieving good results in 86% of the cases.[38] Gosens et al.[39] reported no functional loss in their patients although some complained of pain, weakness, and crepitations on shoulder movement. When associated with other injuries, the range of motion was limited when compared to the contralateral limb after conservative management, which was not the case in isolated scapular fractures.[39] Using the Disabilities of the Arm, Shoulder and Hand (DASH) score, Simple Shoulder Test (SST) score, and the range of motion, Gosens et al.[39] showed a difference between the patients with an isolated scapular body fracture and the patients with a multi-trauma, in which the latter had a lower functional outcome. This may be due to a delay in diagnosis, the presence of associated injuries, required immobilization for coexistent thoracic or shoulder injuries, and thoracoscapular joint abnormalities due to associated fractures in the ribs.[39] Cases of nonunion after conservative management of scapular body fractures were reported in the literature but these remain rare and conservative management for isolated fractures is still the gold standard.[40-42] In fact, scapular body fractures have a better functional outcome in the next 6 months after surgeries when compared to conservative treatment whereas at 12 months functional outcome is the same.[43,44]

Furthermore, Kannan et al.[8] reviewed 3 articles[39,45,46] on managing scapular body fractures and found high satisfaction in both patients treated conservatively and operatively. The indications of surgical management were 100% translation of the lateral border fragments, 30° of angular deformity of the lateral border and glenoid fossa, > 15 mm medialization of the glenohumeral joint, > 25° angulation in the semi-coronal plane, intra-articular extension, > 10 mm displacement after double disruption of SSSC, and fragment penetration into the thoracic wall. Moreover, there was no significant advantage of surgical treatment over conservative treatment ($p = 0.28$), but this may be due to the fact that none of the patients managed conservatively had an indication of operative management.[8]

Therefore, conservative management of scapular body fractures is recommended unless the fracture is not isolated, a 100% translation of the lateral border fragments is present, there is a 30° of angular deformity of the lateral border and glenoid fossa, the medialization of the glenohumeral joint > 15 mm, the angulation in the semi-coronal plane > 25°, an intra-articular extension, displacement after double disruption of SSSC > 10 mm, and fragment penetration into the thoracic wall.

SCAPULAR NECK FRACTURES

Fractures of the scapular neck used to be treated solely using conservative management.[47] This is not the case now as operative management is playing a major role in the treatment of such fractures.[47] Some disadvantages of conservatively treating these fractures were reported in the literature such as residual stiffness, subacromial pain, and abduction dysfunction, but no study reported a functional disability.[48,49] Another adverse effect was translational displacement of fracture fragments with scapular neck shortening.[50]

Of all isolated neck fractures, 83% are managed conservatively with good results being reported in 77% of the cases.[38] The average Constant score for scapular neck fractures managed nonoperatively is around 78.83 with no significant differences between anatomical and surgical neck fractures.[51] When comparing scores between groups of patients, it was noted that the presence of associated injuries, such as those of the clavicle, affected the score and the functional outcome of the conservative management, but gender did not.[51] Nevertheless, when associated with clavicle fractures, conservative management of both fractures reports good outcomes in 94% of the cases.[38] Furthermore, Romero et al.[52] found, using the Constant-Murley score, that when treated conservatively, scapular neck fractures can cause functional problems in patients whose GPA is lower than 20°. Moreover, van Noort et al.[53] found that when the GPA is higher than 20°, the Constant-Murley scores of patients with scapular neck fractures treated conservatively were excellent. Thus, when comparing the GPA to the Constant-Murley scores, a positive correlation was found.[51]

A systematic review by Kannan et al.[8] studied the management of scapular neck fractures by including three articles.[16,50,51] In this review, half of the patients managed conservatively had a displacement < 10 mm and reported satisfactory results in 94.7%.[8] The remaining half had a displacement > 10 mm reporting satisfactory results in 15.7%.[8] All of the patients who were treated operatively had satisfactory results.[8] After analysis, it was shown that displaced neck fractures were better treated surgically ($p < 0.0001$).[8]

After a three-dimensional reconstruction, scapular neck fractures can be classified after assessing the integrity of the CA and coracoacromial (CC) ligaments into three types: stable fractures (both ligaments are stable), fractures with rotational instability (ruptured CA ligament with an intact CC ligament), and fully unstable fractures (both the CA and CC are ruptured).[47] Surgical management is indicated in scapular neck fractures when there is a medial displacement of the glenoid neck fragment by more than 1 cm and/or anterior angulation equal to or greater than 40°.[16] Surgical management of highly displaced scapular neck fractures has excellent outcome and improves the restoration of the initial biomechanics.[16] Anatomical reduction of the fracture with excellent functional outcome was achieved in 12 patients (86%) and with good functional outcome in 2 patients (14%).[16]

When it comes to scapular neck fractures extending to the body, Esenkaya[54] have found satisfactory results in all 9 patients after treating them operatively. In contrast, Ada and Miller[25] have found unsatisfactory results in 50% of 16 patients with the same type of fractures after treating them nonoperatively.

Therefore, it is recommended to treat scapular neck fractures conservatively, unless the GPA is < 20°, a medial displacement of the glenoid neck fragment by more than 1 cm is present, anterior angulation equal to or greater than 40° is present, the scapular neck fracture is fully unstable, and the fracture is extending to the body.

INFERIOR ANGLE OF THE SCAPULA

The majority of fractures of the inferior angle of the scapula are thought to be high-energy injuries, and they most frequently affect young adult males.[55] Numerous muscle attachments, including the latissimus dorsi and serratus anterior, surround the lower scapula.[55] In fact, the long thoracic nerve, which innervates the serratus anterior muscle, can be injured, the result of which is the characteristic winging of the scapula.[55] Therefore, patients exhibiting scapula winging, with fractures of the inferior angle of the scapula, can predict fracture displacement in most cases, thus having an impact on management and result.

A systematic review was done by Mousafeiris et al.[55] reviewing 17 articles about fractures of the inferior angle of the scapula.[20,41,43,56-69] This article showed that the success of conservative care was inversely correlated with the degree of displacement; more than 80% of nondisplaced

fractures were successfully managed conservatively compared to almost 90% of displaced fractures where conservative management failed.[55] In fact, when displaced, if treated conservatively, fractures of the inferior angle of the scapula result in nonunion and will most probably require operative fixation later on.[43,69] Overall, surgical treatment produced 100% favorable outcomes for both the first and subsequent surgically treated fractures.[55] In contrast, the majority of the cases that received conservative care involved nondisplaced fractures and it succeeded in most of them.[55] In minimally displaced inferior angle of the scapula fractures, Brindle et al. reported good results of nonoperative treatment (using nonsteroidal anti-inflammatory drugs and physiotherapy) with a complete return

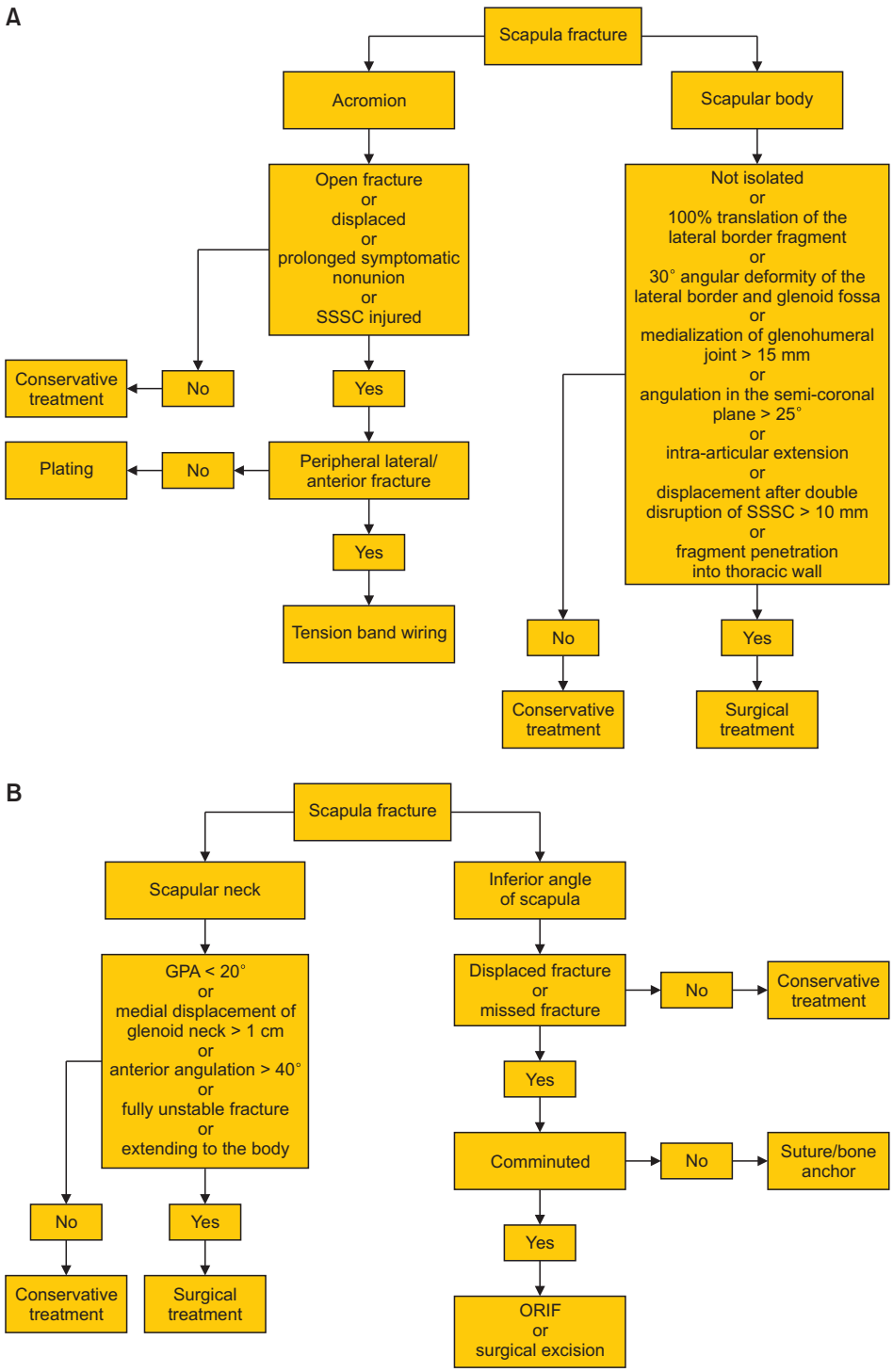

Fig. 2. (A, B) Algorithm for the management of scapula fractures. SSSC: superior shoulder suspensory complex, GPA: glenopolar angle, ORIF: open reduction and internal fixation.

of function and range of motion in young patients.[64]

Moreover, the most frequent operation performed as initial treatment and reported overall was suture repair.[55] However, in cases where the initial conservative therapy was unsuccessful, removal of the misplaced fragment was most commonly performed, which was followed by suture repair, all producing fruitful results.[55] There have also been reports of missed diagnoses and thus missed treatments; of the missed fractures, the majority were treated surgically,[55] and only Ogawa et al.[59] reported a missing fracture that was conservatively treated. Furthermore, in a recent series of fractures of the inferior angle of the scapula, the majority of fractures were nondisplaced and treated conservatively; however, three displaced fractures were operated on, and all fractures had excellent or good outcomes.[70]

Therefore, for nondisplaced fractures of the inferior angle of the scapula, conservative care should be used since it results in successful treatment. Surgical management should be reserved for displaced fractures and for missed fractures in order to prevent treatment failure. Suture/bone anchor repair should be taken into consideration first in cases of displaced fractures to preserve the displaced fragment and restore the anatomy with the least amount of intervention. However, open reduction and internal fixation or surgical excision can be taken into consideration if suture/bone anchor repair is not an option such as in cases of comminution. Nevertheless, exceptions exist such as Edgington et al.[60] who effectively used conservative treatment for a displaced fracture or Franco et al.[66] reporting displacement of a conservatively treated nondisplaced fracture in an old patient.

SCAPULAR FRACTURES IN PEDIATRIC PATIENTS

Both nonoperative and surgical treatment outcomes are described as excellent or very good in the literature.[71] However, some complications of nonoperative treatment were reported. Montgomery and Loyd[72] reported a fair outcome after conservative treatment of a youngster with a coracoid fracture that was accompanied by an acromioclavicular dislocation. Another case is a painful nonunion of the inferior angle of the scapula in a 16-year-old boy, which necessitated revision surgery, fragment excision, and muscle reinsertion 3 months after injury.[65] In addition, a 15-year-old child with an originally overlooked and nonoperatively treated fracture of the scapular body was documented in a case of delayed healing.[73] Furthermore, with a cortical bone graft and tension band wiring, Warner and Port successfully totally repaired nonunion of the lateral spine in a 16-year-old girl.[74] Nevertheless, to our knowledge, patients with pediatric scapular injuries have not been described with late sequelae, particularly development abnormalities.

CONCLUSIONS

Controversy still exists on whether to go for conventional or operative treatment of scapular fractures, which is why this review was written and an algorithm of management was proposed (Fig. 2). Most of the scapular fractures can be treated conservatively except in certain conditions that can be common for all of the different scapular fracture types as well as specific to each one. Common indications include displacement, unstable fractures, open fractures, and failure of conservative management (where surgery is not indicated).

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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