Fracture Mapping of the Scapula via Computed Tomography Images

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Introduction: Fractures of the scapula present as a unique and challenging set of issues. Scapula fractures are very uncommon and comprise 1% of all reported fractures, and 3% to 5% of all shoulder girdle fractures. The protective nature of the surrounding boney and soft anatomy makes it difficult to impart large forces to the scapula [1]. Defining the patterns of fractures occurring in the scapula is a first step to understanding the proper course of treatment. Several classification systems have been developed. However, these classification systems lack clinical validation and do not encompass newly developed technologies which tend to provide better resolution and processing of the fracture patterns. The primary aim of this study was to create a frequency map of occurring scapula fractures from Computed Tomography (CT) images. The use of CT images and three dimensional rendering will allow for a more thorough investigation of these difficult fracture patterns.

Materials and Methods: From 1998 until 2006 a prospective scapula database collected 105 consecutive patients with surgical intervention of a scapula fracture. Using three dimensional rendering an anterior-posterior (AP) and or in association with a posterior-anterior (PA) image was created to demonstrate the pattern of fracture occurrence. Scanned images from each patient were imported into Macromedia Fireworks (Adobe Systems, San Jose, CA) to be superimposed and oriented to fit the model scapula image. A standard scapula was selected as the foundation for the bony anatomy of all maps due to the varying size and shape of the scapula between patients. Orientation included rotation as well as mild distortion through stretching or compressing different aspects of the image. Proper rotation and distortion was done by aligning specific scapula landmarks; the superior and inferior glenoid, inferior scapula angle, medial scapula spine, and the acromion. Once proper anatomical alignment was obtained, fracture lines were identified and were traced on top of the combined CT and model scapula. The CT view imported to Fireworks was then removed and individual fracture sites were overlapped looking for a pattern of fractures.

Results: Of the 105 patients that were collected into the scapula database, 90 patients received operative management, and thus met the inclusion criteria for this study. The findings of most common fractures were divided into three groups based on lateral fracture lines; inferior glenoid neck, spinoglenoid notch, and articular fractures (Figure 1a-c).

Discussion: From this series it was evident that the fracture lines occurring in the scapula fell into distinct groupings. Most fractures occurred inferior to the articular surface followed by those occurring just superior to the articular surface. These fracture lines coincide with the thinnest cross section of bone in the area surrounding the source of impact of the humerus through the glenoid. After the fracture initiates at the glenoid it generally continues to propagate. During this progression, the path followed most commonly coincides with areas in between opposing muscle groups or through regions with thinner areas of bone. The majority of the fracture lines predictably travel inferior to the scapular spine where there is a large moment arm attached to a very strong muscle group, the trapezius. Another significant fracture pattern is one traveling from the spine down through the body of the scapula. This pattern not only travels through the thinnest section of the scapula, but it also splits powerful muscle groups applying medializing and lateralizing forces. Further evidence of the role of these opposing forces comes from the typical exit point of this fracture occurring just inferior to where the rhomboids major should insert a major medializing muscle group, and the insertion of teres major; a lateralizing muscle. These observations strongly support the plausibility of fracture patterns due to both geometry and muscle forces and raises the question of whether the lines occur due to the initial impact or if the initial impact simply destabilizes this complex system and the muscles pull the bone apart. It is clear from the literature that a comprehensive study linking pattern with outcome would be a valuable addition in the treatment of these fractures. This study can serve as the basis, while the patient outcomes are tracked over time to investigate possible links between fracture pathology and patient functionality. Surgical indications must be reevaluated, as surgery is both expensive and invasive. However, proper biomechanical restoration of the shoulder girdle is essential to long-term success in outcomes. These two factors may be opposing in many cases and should be carefully evaluated as more information is available. The results contained within may be helpful in furthering our understanding and use of existing classification systems, provide a roadmap for surgical approaches, as well as aid in the development of optimal implants to fix such fractures.


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Of all the reviewed fractures, 67.8% have a component involving the inferior glenoid neck, 71.1% have a component involving the scapula body just inferior to the medial spine, 16.7% of fractures had an articular component, and 22.2% traveled through the spinoglenoid notch. Due to the fact that most fractures occur from a force imparted through the glenoid by the humerus, the fractures were broken down into three groups surrounding the glenoid. The predominance of a medial involvement mainly just inferior to the scapula spine, 83.61%, as well as a less predominant fracture pattern in the inferior medial third of the body of the scapula, 44.3% (full) and 14.7% (partial), is evident both qualitatively and quantitatively. The spinoglenoid notch fractures also show a similar type of pattern with 65% of fractures involving the medial border inferior to the spine, 60% involving the area just inferior to the glenoid, and 45% involving the inferior medial third (25% full fracture lines, 20% partial). It is the articular fractures that break these somewhat predictable patterns, evident both qualitatively and the qualitatively (Figure 1c). The highest repeatable fracture is an involvement with the area just inferior to the medial spine in 53.3% of the cases.