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EVALUATING THE FIT OF CURRENT ANATOMICAL SCAPULA RECONSTRUCTION PLATES: A STUDY USING FIFTY SCAPULAE

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ABSTRACT

Open Reduction and Internal Fixation (ORIF) of scapula fractures have increased in numbers recently. This is due to better functional outcomes achieved post-ORIF than non-operative management techniques. In South Africa, there is only one available supplier for anatomical contoured scapula plates used in the ORIF. This study examines the fit of these plates on the bony topology of fifty healthy scapula. It was observed that the short medial body plate performed the best in adhering to the bone topology followed by the short acromion plate. The glenoid plate and the long acromion and body plates were not adequately designed to fit their intended regions on the scapula. In conclusion, this study highlights the drawbacks in design of current commercial plates available for ORIF of scapula. Further studies are needed in order to evaluate the quantitative-fit performance of these plates on fracture scapula surfaces.

Keywords: scapula fracture, anatomical plate design, scapula ORIF, fit analysis, South Africa.

INTRODUCTION

The shoulder is the most active region of the upper body and a large part of this activity arise from the glenohumeral joint (Figure 1). The glenohumeral joint is formed by the articulation of the humerus and the scapula. Any injury or disease to either of the bones, in the form of fracture or osteoarthritis, reduces the bones' ability to achieve the permissible range of motion. This affects the injured individual's quality of life [1,2].

Clinical interventions for scapula fracture managements can be broadly classified into non-invasive treatment and ORIF of the fractures. Although non-invasive management strategies do not require the patients to go through the surgical process, it rarely provides adequate restoration of movement in the injured shoulder [3]. Moreover, there is no consensus regarding the optimum way to provide the non-invasive treatment to scapula facture patients. These drawbacks have led the surgeons to adapt the ORIF option to manage fractured scapula with displaced fracture fragments [3].

A study performed on humeral fractures in the United States of America (USA), reported that 70.5% of the patients were treated using ORIF surgery over a period of eight years [4]. Although post-fracture ORIF of scapula is rare, they are not uncommon. On an average 21.4 cases of scapula fractures are repaired using ORIF in the USA [5]. Due to the prevalence violence and contact sports in South Africa, upper body injuries are quite common. In the literature, a study found that 56.7% of upper limb gunshot injuries cause upper limb fractures. Out of these fractures 10.6% gunshots fractured the scapula [6]. While most of these scapulae were fixed using conservative technique, 1 scapula was fixed using ORIF surgery. Scapula had the one of the lowest ORIF procedures (14%) performed compared to humerus (22%), radius (19%), and ulna (14%) [6].

During the surgical management (ORIF) of scapula fractures, the surgeons anatomically reduce the fractured and displaced segments of the bone. Then one of the methods of joining these fractured segments back is to connect them using pre-contoured anatomical reconstruction plates [2]. It has been reported that better healing of the fractured bones and faster

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return to functional range of motion can achieved using such ORIF surgeries of scapula [3,5].

A set of anatomical reconstruction plate, for scapula, consist of body plates, glenoid plate, and acromion plates. These anatomically pre-contoured reconstruction plates [8] are designed according to the shape of the specific segment of the scapula bone, as shown in figure 2. Often these plates do not adequately adhere to the topology of the scapula due to high variance in the bone shape and surface contour [9]. Reduced usage of ORIF for scapula, as reported in the literature, might be due to the design of the available commercial scapula plates.

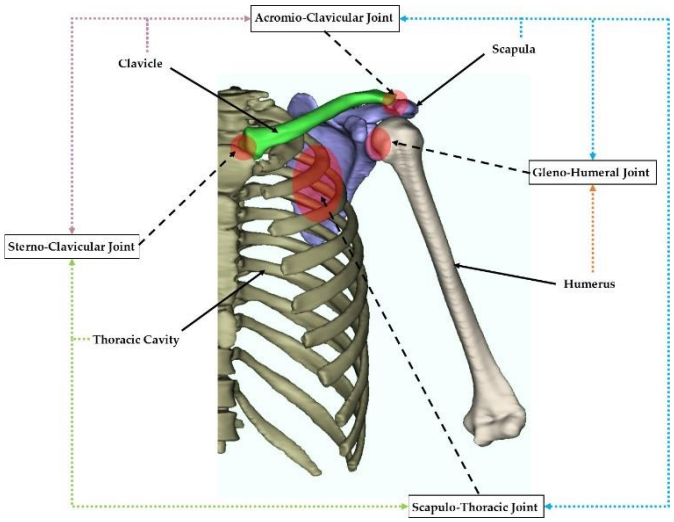

FIGURE 1: The anatomy of the shoulder joint complex along with the various constituting articulations.

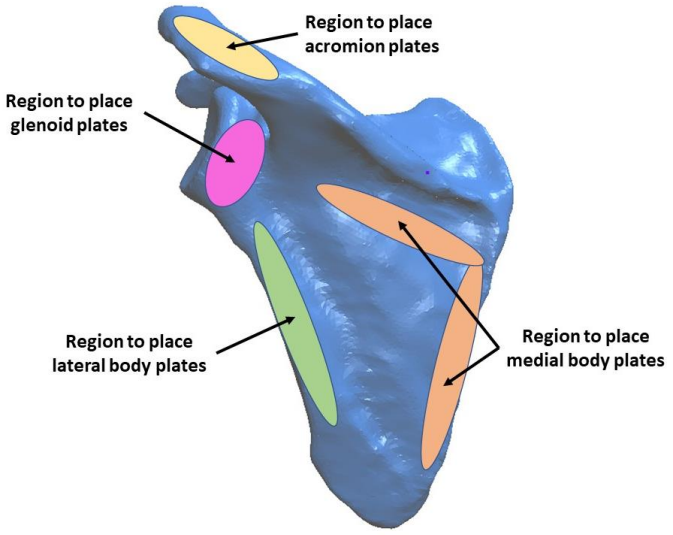

FIGURE 2: The designated regions on the scapula bone for the surgical implantation of pre-contoured anatomical plates during ORIF.

There is no extensive study which examines the fit of the scapula plates on the scapular surface. Park et al. had previously studied 12 scapula specimens using manual plate templating using a computer software [10]. The study population in the previously mentioned study [10] was inadequate to consider morphological variation and their method was prone to error arising from the individual's efficiency in using the computer program. This study aims at investigating the fit of the only set of scapula reconstruction plate, provided by Acumed® [8], available to surgeons in South Africa.

METHODS

Departmental review committee (DRC) approval was obtained before initiating this study from the Department of Surgery, Groote Schuur Hospital, University of Cape Town. Fifty adult and healthy scapulae specimen (N=50) were obtained from the museum at the Faculty of Health Sciences, University of Cape Town. There were no soft tissues or sign of degeneration on the scapula. 64% of the cohort was right sided scapula and the rest were left sided. In a previous study [7] performed at the Groote Schuur Hospital, it was reported that over a six-year period (2001–2006) thirty-one adult scapula fractures were treated using ORIF. Therefore, the sample size of this study can be considered adequate to represent fractures observed by the surgeon over a lengthy period.

Two orthopaedic registrars simultaneously examined the fit of each type of plate (Figure 3) on every scapula bone. The examination was performed by templating the plates on the bones' designated regions on the scapula surface (Figure 2). After templating, the observations were classified as anatomical fit, intermediate fit & no fit and scores (*s*) were assigned (Table 1). Required measurements, to determine the type of fit, were performed using a Vernier caliper.

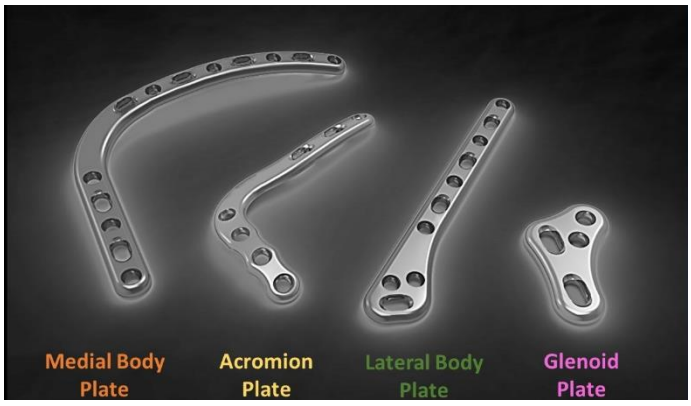

FIGURE 3: Current commercial plates designed for various regions of the scapula. The titles of each plate are color coded to provide a better understanding to the reader. It is recommended to view the current image and Figure 2 together in order to understand the alignment of the anatomical plates on the scapula bone [8].

The average score (S_{avg}) for each of the six plates was calculated by the equation (1). Using this scoring system, it was anticipated that a reconstruction plate with the final average score ~10 would have anatomically fit its region of implant for most of the scapula, whereas a plate with an average score ~0 would suggest that it had failed to optimally fit its designated implant region in most of the scapula. It should be noted that the medial body plate and the acromion plate come in two sizes, short and long. Both the plates were included in the study, but the results were clubbed together.

TABLE 1: Description of the observations after templating the plates on the designated zones on the scapula surfaces.

Classification		Description	Score (s)
1	**Anatomical Fit**	No observed plate overhang and the gap between the plate and the bone surface is < 2mm.	10
2	**Intermediate Fit**	No observed plate overhang and the gap between the plate and the bone surface in > 2mm.	5
3	**No Fit**	The plate overhangs from the scapula surface and can not be contained within the scapula anatomy even after bending.	0

$$S_{avg} = \frac{\sum_{i=1}^{i=N} s_i \ldots\ldots\ldots s_N}{N} \quad (1)$$

RESULTS

The outcomes of this study are presented in Figure 4. The average score of short medial body plate was the highest (S_{avg} *=7.7*) while the average score for the glenoid plate was the lowest (S_{avg} *= 0*). The short medial body and the short acromion plates had high number of anatomical fits, 60% and 32% respectively, followed by the lateral body plate (26%).

Long acromion and long medial body plates had high number of no fits, 44% and 66% respective, while the glenoid plate had 100% no fit. There was a positive correlation between the average score and the anatomical fit percentage whereas the average score was inversely related to the no fit percentage. The primary reasons for the inadequate fit for the plates was overhang and the secondary reason was observed to be bone – implant gap. It was also observed that the plates that fit the bone anatomy were challenging to be stabilized by screw.

CONCLUSIONS

The current study was able to demonstrate that shorter plates, in general, fit without any overhang on the scapula surface. Re-designing of glenoid plates are recommended as the current design provide inadequate congruency to the peripheral region of the glenoid fossa. Moreover, the glenoid plates were also observed to resist bending which made it difficult to reduce the bone – implant gap. This study also presents a dependable methodology to access scapula plate fit characteristics which can be included in future research.

Further research is recommended by adapting this methodology to evaluate fractured scapulae to quantify the fit of pre-contoured scapula reconstruction plates. We also recommend involving experienced surgeons to evaluate the quantitative-fit performance of the commercial scapula plates and to provide clinical perspective.

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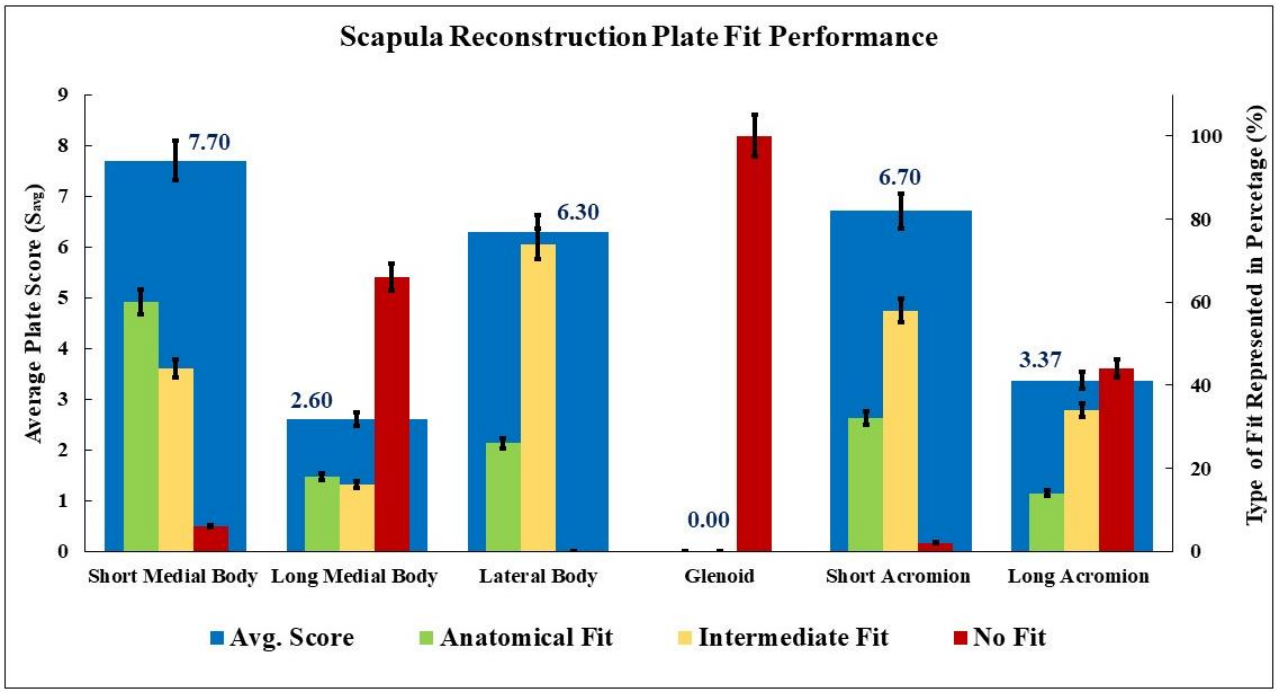

FIGURE 4: Final results from the scores presented as average scores (values provided) for each plate and their observed fit in (%) along with 5% error bars.