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ORIGINAL ARTICLE

Comparative analysis of 2 glenoid version measurement methods in variable axial slices on 3-dimensionally reconstructed computed tomography scans

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Background: Most glenoid version measurement methods have been validated on 3-dimensionally corrected axial computed tomography (CT) slices at the mid glenoid. Variability of the vault according to slice height and angulation has not yet been studied and is crucial for proper surgical implant positioning. The aim of this study was to analyze the variation of the glenoid vault compared with the Friedman angle according to different CT slice heights and angulations. The hypothesis was that the Friedman angle would show less variability.

Materials and methods: Sixty shoulder CT scans were retrieved from a hospital imaging database and were reconstructed in the plane of the scapula. Seven axial slices of different heights and coronal angulations were selected, and measurements were carried out by 3 observers.

Results: Mid-glenoid mean version was −8.0° (±4.9°; range, −19.6° to +7.0°) and −2.1° (±4.7°; range, −13.0° to +10.3°) using the vault method and Friedman angle, respectively. For both methods, decreasing slice height or angulation did not significantly alter version. Increasing slice height or angulation significantly increased anteversion for the vault method ($P < .001$). Both interobserver reliability and intraobserver reliability were significantly higher using the Friedman angle.

Conclusion: Version at the mid and lower glenoid is similar using either method. The vault method shows less reliability and more variability according to slice height or angulation. Yet, as it significantly differs

This study obtained the approval of the local health district ethical committee (North Sydney Local Health District, LNR/16/HAWKE/37).

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from the Friedman angle, it should still be used in situations where maximum bone purchase is sought with glenoid implants. For any other situation, the Friedman angle remains the method of choice.
Level of evidence: Anatomy Study; Imaging

Keywords: Glenoid; version; vault; Friedman angle; CT scan; axial slice; comparative analysis

Glenoid version plays a crucial role in many aspects of shoulder surgery, ranging from glenohumeral instability[6,16,20,22] to reverse[14,17,28] and anatomic[5,7,13,27,30] total shoulder arthroplasty. It is particularly important in anatomic total shoulder arthroplasty, where glenoid resurfacing remains the weak link in implant survivorship, with malposition being the main cause of failure.[7,13,29,30]

Many preoperative radiologic methods have been proposed to assess glenoid version, mostly based on computed tomography (CT) scans using simple axial slices, 3-dimensionally (3D) corrected slices, or even direct 3D viewing of the glenoid.[1,9,18,19,21,23,24,28] Lately, patient-specific guides based on preoperative imaging have also gained in popularity in arthroplasty with severe glenoid deformity, and they provide high accuracy in implant positioning.[11,15,25] The easiest and most readily available method of assessing glenoid version is on preoperative non-reconstructed CT scans, as 3D correction needs an extra step that can only be carried out using specific viewing software programs.

Although the most popular measurement method remains the Friedman angle[9] (Fig. 1, *A*), several limitations have been reported, such as its dependency on the variable shape of the medial border of the scapula,[3,19] which is, moreover, often not included in the radiologic field of shoulder CT scans.[19] Furthermore, this method has been shown to vary according to the orientation of the body of the scapula in the sagittal and frontal planes, making it unreliable on non–3D corrected CT scans.[2,3,10,12,26] Recently, Matsumura et al[19] have shown that measuring the version according to the tip of the glenoid vault (Fig. 1, *B*) is also reliable, less prone to variation between patients, and more sensitive to changes in arthritic glenoids.

However, most of these measurement methods have only been validated on axial slices at mid-glenoid height, which does not represent the different intraoperative settings. In the case of reverse shoulder arthroplasty, the introductory pin is usually inserted in the lower portion of the glenoid, whereas the guide is usually aligned with the superior border of the glenoid in anatomic shoulder arthroplasty. Screws for baseplates or metal-backed glenoids are also not inserted at the mid-glenoid height but rather above or below it. Therefore, it is mandatory to know whether these measurement methods are still reliable above and below the level at which they have been validated. In addition, the vault method has been validated on 3D corrected axial slices, and its reliability in non-corrected slices remains unknown.

The aim of this study was thus to further extend the validity of the vault measurement method by carrying out a comparative analysis with the Friedman angle by varying slice height and angulation in the coronal plane. The hypothesis was that the vault method would show less variability than the Friedman angle.

Material and methods

Study subjects

CT scans of 60 right shoulders were retrieved from a major Australian public hospital imaging database. The inclusion criteria were CT scans involving the whole body of the scapula with normal or arthritic glenoids. Any fracture involving the scapula and glenoids with post-traumatic or congenital deformities were excluded.

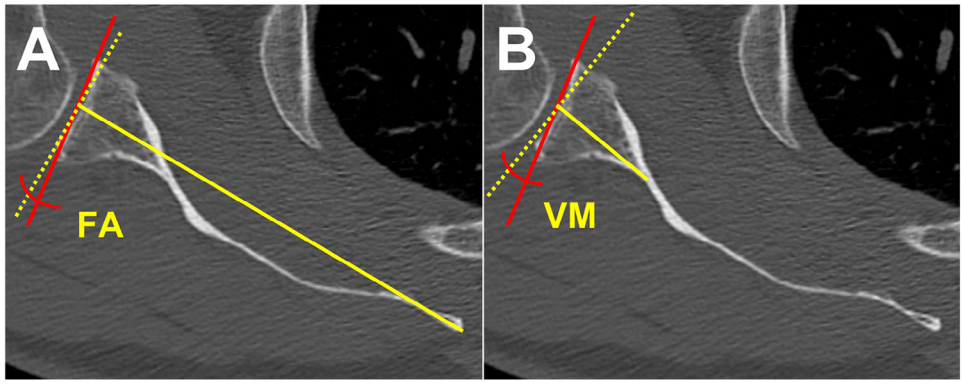

Figure 1 Axial computed tomography slice showing glenoid version measurement according to the Friedman angle (*FA*) (**A**), taking the medial border of the scapula as the reference point, and the vault method (*VM*) (**B**), taking the tip of the glenoid vault as the reference point.