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Original article

COMPUTER TOMOGRAPHIC ANALYSIS OF THE GLENOID COMPONENT IN REVERSE SHOULDER ARTHROPLASTY

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ABSTRACT

The positioning of the glTenoid component in RSA (Reverse Shoulder Arthroplasty) is one of the factors determining implant survival and postoperative outcomes. Therefore, accurate determination of the glenoid version and inclination in RSA is essential for the surgeon - preoperatively to plan his work and postoperatively - to assess the outcome. Excessive retroversion and superior inclination are prerequisites for unsatisfactory results and are associated with a high frequency of revisions.

The glenoid inclination is often described as the angle between the glenoid fossa line and the suprascapular reference line. The study included a 2-year follow-up of patients with reverse shoulder arthroplasty in the Department of Orthopedics. The analysis is based on pre / postoperative CT and three-dimensional reconstruction using Medi Cad software. A comparative analysis was made with the results obtained by X-ray examination.

The results showed a high incidence of superior inclination of native glenoid fossae. The obtained ß-inclination angle averaged 13.8 °, and the difference in this radiographically measured parameter was 7.3 °. CT analysis preoperatively significantly improves the position of the glenoid component and avoids the superior inclination of the baseplate of the prosthesis.

Keywords: RSA, ß-angle, CT, glenoid inclination,

INTRODUCTION

Reverse shoulder arthroplasty (RSA) for osteoarthritis of the shoulder (omarthrosis), degenerative arthropathy due to rotator cuff rupture, or proximal humerus polyfragmental fracture is recommended reatment, especially in elderly patients. The goal is to restore limb function and range of motion by balancing muscles and replacing damaged joint surfaces. Whether it is a degenerative or traumatic cause, the positioning of the components is extremely important for the restoration of the native kinematics of the joint. One of these elements is the glenosphere because it determines the center of rotation of the new joint and hence the function of the shoulder muscles. Improper positioning of the glenoid component, and especially its inclination, leads to reduced implant survival and poorer functional results.

The orientation of the glenoid fossa relative to the scapula is generally defined as an inclination (in the frontal plane) and glenoid version (in the axial plane, transverse to the body of the scapula). Glenoid inclination is defined as the angle of the glenoid fossa relative to the scapular axis and is defined as a potential cause of complications after shoulder prosthesis [1].

The superior anatomical inclination of the glenoid fossa is associated with an increased incidence of rotator cuff ruptures and superior migration of the humeral head. [2] In shoulder arthroplasty, the exact positioning of the glenoid in the vertical plane is critical to the functional outcome and survival of the implant [3].

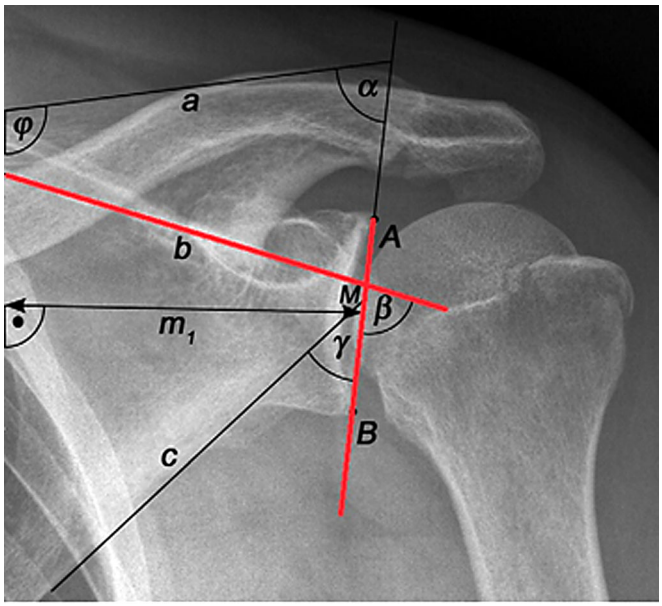
Glenoid inclination and version are measured by various methods, including both cadavers and radiographs, 3D - CT and three-dimensional models [4]. Most modern methods for measuring glenoid inclination are based on imaging [5, 3]. One of the methods with great accuracy and reliability is the one described by Maurer, who determines the so-called ß-angle, both radiographic and CT [5].

There are already developed models for three-dimensional (3-D) calculation based on two-dimensional CT scans of various parameters, mainly glenoid inclination, but they are not yet fully validated [6]. With the growing popularity of reverse arthroplasty, the incidence of subsequent complications inevitably increases. Although some of them are typical for each arthroplasty, others are specific for reverse prosthetics: scapular notching, instability, and tuberosities migration [7].

The superior tilt of the baseplate is associated with an increased incidence of complications due to increased stress in the bone-implant interface, and impingement between the polyethylene insert and the scapular neck [8]. Last but not least, this leads to a reduction in the volume of movement [9, 10]. The optimal position based on the glenosphere is inferiorly positioned at the edge of the glenoid fossa and with an inferior inclination. This allows, after assembling the glenosphere, to be 2-4 mm below the edge of the glenoid, which prevents scapular notching and complications associated with it [11, 12].

Preoperative planning and postoperative assessment of each arthroplasty are performed radiographically as standard. However, computed tomography in combination with reliable software provides significantly more information both preoperatively and postoperatively. Such important parameters as the glenoid inclination can be determined on the basis of reliable values - such as the ß-angle determined by Maurer, which is the angle formed between the floor of the supraspinatus fossa and that of the glenoid. (figure 1)

Fig. 1. Determination of glenoid inclination by ß-angle.



CT gives a more accurate measurement of glenoid anatomy preoperatively and postoperatively at the position of the implants [13]. Of course, there are drawbacks due to the presence of a metal "echo" and the lack of accurate visualization of the polyethylene insert.

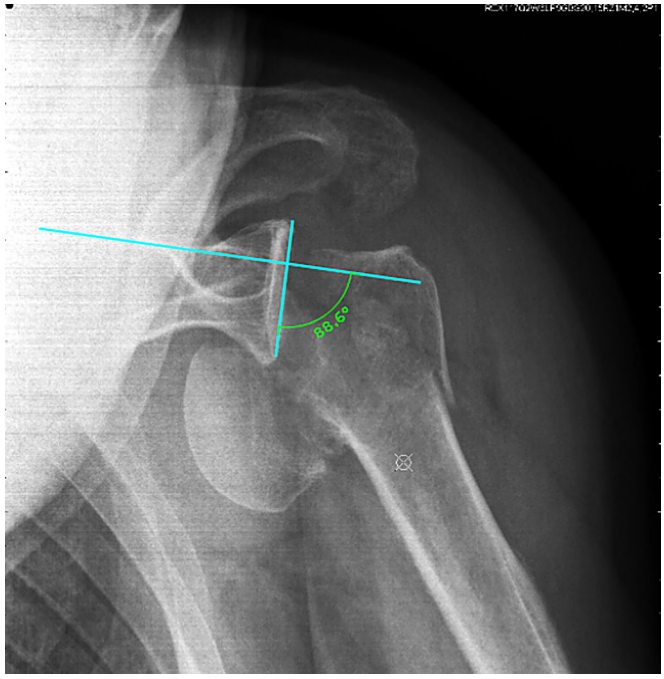
MATERIAL AND METHODS

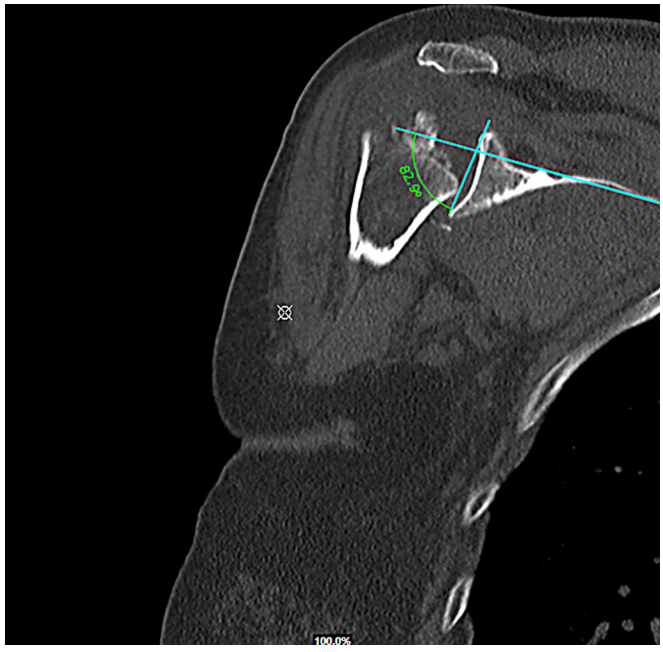
The study was retrospective and included 34 patients with reverse shoulder arthroplasty (RSA). The distribution by sex is in favor of women - 32: 2; the age range is 54-76 years. The follow-up period is from 4 months to 18 months. Preoperative/postoperative radiographs were performed in all patients as standard procedure. In 22 patients we performed CT preoperative and postoperative analysis of the inclination of the native glenoids and the position of the implants postoperatively, with emphasis on the inclination of the glenosphere.

For the purpose of the study, we use the ß-angle described by Maurer, which is measured on plane radiographs and CT scans in neutral rotation of the limb [5] (Fig. 2). This angle is determined according to the method described above - the intersection between the lines drawn trough supraspinatus fossa and the glenoid fossa and the resulting angle. The sclerotic line, which forms in the upper 1/3 of the scapula and represents the supraspinatus fossa, is determined on plane radiographs. The glenoid fossa is defined as the line connecting the two tubercles of the glenoid. On CT scans, a section is selected that includes these two anatomical objects as much as possible. They are constant as an anatomical object and unchanged from the different position of the shoulder blade or the patient's body.

The glenoid inclination in these measurements resembles a 90 ° degree angle, with values above 90 ° indicating inferior inclination, while those below it indicate superior inclination. The determination of this parameter by X-ray and CT was performed using MediCad software.

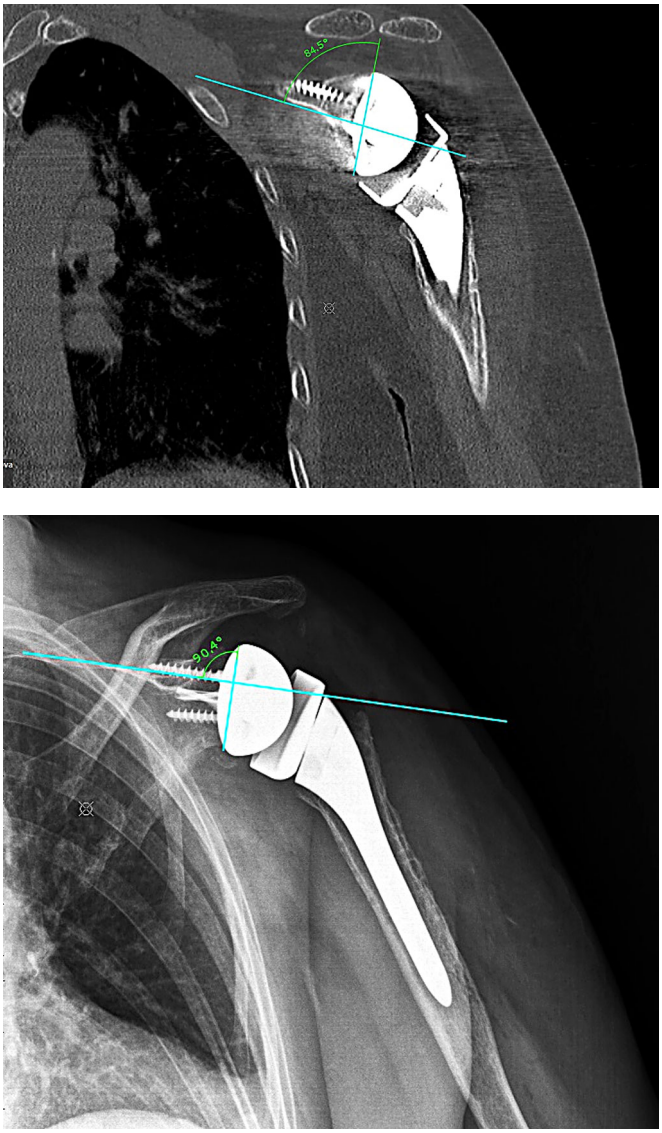
Fig. 2. ß-angle of radiography and CT preoperatively.





It is extremely important in CT examination to suppress the so-called metal "echo", for better visualization of target structures in the analysis, namely - baseplate and supraspinatus fossa (Fig. 3). In postoperative analysis, we have sought to visualize the central peg of the baseplate in order to accurately determine its position.

Fig. 3. Postoperative ß-angle of CT and radiography



RESULTS

The preoperatively measured ß-angle of CT was on average 77.3 ° (65.2-89.7). The measured postoperative ß -angle of CT is on average 90.9 ° (85.2-94.5). The difference in the value of this parameter pre- / postoperatively averaged 13.8 °, which indicates a relatively high frequency of superiorly inclined native glenoids. On the other hand, it shows a good correction of the inclination and a good position of the baseplate of the glenoid component of the prosthesis. The measured postoperative ß -angle of radiographs is on average - 83.6 ° (74.3 ° -88.5 °), and the difference from that measured on CT is on average 7.3 °. This can be interpreted as evidence of a significantly more accurate determination of the required parameters of CT.

DISCUSSION

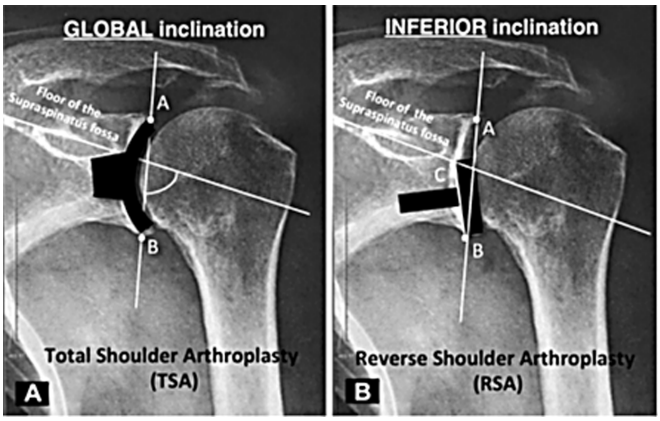
The glenoid inclination is a parameter that is calculated from relatively constant anatomical markers. According to Maurer, the acromion, the medial, and the lower edge of the scapula are structures with great variation depending on the position of the patient and the scapula itself [5]. Therefore, they are not recommended for determining the position of the glenoid component in RSA. The author defines the ß -angle as resistant to up to 20 ° rotation of the blade, which makes it reliable for determining the positioning of the baseplate in reverse shoulder arthroplasty relative to other similar parameters. In the same study, the measured preoperative ß-angle averaged 84.7 °, which is close to that measured in our study.

The data from the follow-up of the patients in our study and the degree of inclination of the baseplate of the glenosphere show a very good degree of correction of the initial inclination, which is a prerequisite for improved rotator cuff function and balancing supraspinatus deficiency. This, in combination with the lateralization of the center of rotation of the shoulder joint, increases the so-called "wrapping angle", which improves deltoid function [14].

In computer-assisted analyzes of cadaver models, superiorly inclined glenoid components are more likely to loosen and scapular notching [14]. This is especially valid for cemented humeral stems, which are common, especially in elderly patients with advanced osteoporosis and a wide humeral intramedullary canal.

A recent Boileau study gives new light on glenoid inclination in preoperative planning and postoperative analysis. The ß-angle is considered as a parameter determining the position of the glenoid component in anatomical shoulder prosthesis (TSA) [11,12]. In RSA, most baseplates are in contact with the lower pole of the glenoid fossa and therefore consider the angle described above to be inaccurate. As proposed by Boileau RSA -angle more accurately represents the inclination of the glenosphere. (Fig. 4)

Fig. 4. RSA- angle calculated Boileau [11]



According to the authors, the inclination of the inferior glenoid is up to 10 ° more than the total inclination of the entire glenoid measured radiographically and CT, which is important in the positioning of the baseplate. Hypothetically, the ß-angle does not accurately reflect the de-

gree of inclination in RSA prosthetics. It is critical to note that the analysis was performed in degenerative changes based on rotator cuff- arthropathy, while the analysis in our study was based primarily on fracture pathology with intact glenoid surfaces.

It is an indisputable fact, that in an effort to give an inferior tilt to the glenosphere, overreaming of the inferior glenoid can occur. This should be avoided due to the risk of medialization of the glenoid component, which has been shown to increase the risk of instability, scapular notching and aseptic loosening [11,12].

Lateralization is a reliable way to prevent these complications - augmented baseplate (Bio-RSA) or inclination using a conical bone graft under the glenosphere's baseplate. [11, 15, 16].

Another clinical study by Valenti demonstrated the lack of scapular notching in 76 patients with two years of follow-up in RSA with metal spacer lateralization [17]. According to some authors, the lateralization of the glenosphere has a greater effect on acromial stress than inferior positioning. Increasing the offset by up to 10 mm increases the risk of acromial fracture by up to 8%. In the patients in our study, we focused mainly on the inferior position of the glenosphere and correction of the inclination. It is critical to point out that we have not considered the change in the center of rotation of the shoulder joint pre/post-operatively.

Along with the inclination and the glenoid version, another parameter is reflected in the positioning of the glenoid component. This parameter is the torsion of the glenoid relative to the scapula. Unfortunately, the longitudinal axis of the glenoid face is not parallel to the body of the scapula and often twists forward relative to it [18]. When glenoid orientation is assessed relative to the scapular body, the risk of overexposure to retroversion is directly proportional to increased inclination and vice versa. Cases of major glenoid retroversion are at risk of underestimating the actual inclination.

The accuracy of determining the glenoid position is significantly better at 3D-CT compared to 2D-CT. Its determination also depends on the different software that is used and can give large variations in the measured values in the same patient [19].

CONCLUSION

Computed tomography analysis in shoulder arthroplasty is essential for the correct positioning of the components. The position of the humeral stem can be reliably determined thanks to the mobility of the limb and the easy differentiation of stable anatomical markers. In the case of the glenoid component, this is not always easily achievable due to the anatomy and position of the glenoid, its relative rigidity and the lack of possibility for three-dimensional orientation. This defines CT as the main tool for preoperative planning and postoperative analysis. The ß-angle is a reliable and easily definable parameter for calculating the inclination of the glenoid component, as one of the most important components for successful RSA replacement. The ability to calculate this parameter on both radiographs and CT makes it reliable for use in clinical practice.

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