

## Anterior deltoid insertion distance to various bony landmarks before and after humeral head lateralization

Humeral baş lateralizasyonundan önce ve sonra anterior deltoid yapışma yerinin çeşitli kemik belirli noktalarına mesafesi

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### ABSTRACT

**Aim:** Moment arm of anterior part of deltoid muscle is increased as working principle of reverse shoulder arthroplasty and anterior part of deltoid muscle insertion could be damaged during proximal humerus surgery. The purpose of the present study was to report distances from various bony landmarks to anterior, superior, medial insertion points of deltoid before and after implantation 5mm thick glenoid implant.

**Patients and Methods:** 12 shoulders of formalin fixed adult cadavers were used at the present study. The distances from greater tubercle to deltoid insertion, anterior-lateral corner of acromion to deltoid insertion, coracoid tip to deltoid insertion, upper pole of glenoid to deltoid insertion, and humeral length (greater tubercle to lateral epicondyle) were measured using digital caliper and measurement tape before and after implantation of 5mm thick pegged glenoid trial (Bigliani/Flatow Total shoulder arthroplasty, Zimmer, Warsaw, IN).

**Results:** At tape measurement, glenoid to deltoid insertion distance was higher at post implant group at right shoulders ( $p=0.04$ ). When all shoulders were compared, coracoid to deltoid insertion distance was higher at implanted group ( $p=0.04$ ).

**Conclusion:** Deltoid insertion lateralization could be detected from the bony landmarks around the glenoid especially the coracoid tip.

Keywords: Deltoid, insertion, coracoid, acromion, great, tubercle.

### ÖZ

**Amaç:** Deltoid kasın anterior kısmının moment kolu, ters omuz artroplastisinin çalışma prensibinde artar ve proksimal humerus cerrahisi sırasında deltoid kas yapışma yerinin anterior kısmı hasar görebilir. Bu çalışmanın amacı 5 mm kalınlığında glenoid implant yerleştirilmesi öncesi ve sonrası çeşitli kemik landmarklardan deltoid anterior, superior, medial yapışma noktalarına kadar olan mesafeleri bildirmektir.

**Hastalar ve Yöntemler:** Bu çalışmada formalle fikse edilmiş erişkin 12 adet kadavra omuzu kullanıldı. 5 mm kalınlığındaki pegli glenoid deneme implant yerleştirilmeden önce ve yerleştirildikten sonra, tüberkulum majus tan deltoid insersiyosuna, akromiyonun anterior-lateral köşesinden deltoid insersiyosuna, korakoid ucundan deltoid insersiyosuna, glenoid üst polden deltoid insersiyosuna olan mesafeler ve humerus uzunluğu(tüberkulum majus tan lateral epikondile) dijital kumpas ve mezuza kullanılarak ölçüldü.

**Bulgular:** Mezura ile ölçümdede, glenoïdden deltoid yapışma yerine olan mesafe sağ omuzlarda implant sonrası grupta daha yükseltti ( $p=0.04$ ). Tüm omuzlar kıyaslandığında, korakoidden deltoidin yapışma yerine olan mesafe implant uygulanan grupta daha yükseltti ( $p=0.04$ ).

**Sonuç:** Deltoid yapışma yeri lateralizasyonu, glenoid etrafındaki kemik landmarklarından özellikle de korakoid ucundan tespit edilebilir.

Anahtar Kelimeler: Deltoid, insersyo, korakoid, akromiyon, tüberkulum majus.

Received Date: 07.11.2018 Accepted Date: 31.03.2019 Published Date: 24.04.2019

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**F**unctional deltoid is critical to reverse shoulder arthroplasty. Especially the anterior deltoid is vital to successful outcome [1-4]. Various cadaver studies examined the insertion anatomy of the deltoid; width, thickness of insertion, distances to nerves, other tendons but to our knowledge, none described the distance of anterior deltoid insertion to bony landmarks which seems to be more suitable to be used intraoperatively to prevent iatrogenic damage to deltoid tendon or evaluating the amount of deltoid lengthening [2,5,6].

Recently Jobin et al. [7] reported that deltoid lengthening described as increased distance from inferolateral acromion tip to deltoid tuberosity on postoperative X-rays was associated with increased active forward elevation for patients treated with reverse shoulder arthroplasty. They advocated measuring the distance from acromial tip to humerus to assess deltoid lengthening which is related to humeral component height or the thickness of the polyethylene liner.

Depending on this, purpose of the study was to determine the distance of the anteromedial insertion point of deltoid to various bony landmarks (anterior corner of acromion, coracoid tip, greater tubercle, top of the glenoid) before and after implantation of trial glenoid insert with thickness of 5 mm. The hypothesis was that 5 mm lateralization of humeral head with insert implantation would be detected from distances measured from bony landmarks at glenoid (coracoid tip and/or top of the glenoid) at adult cadavers.

## PATIENTS AND METHODS

12 shoulders of formalin fixed adult male cadavers were used at the present study in Dokuz Eylül University. The skin and subcutaneous tissue were removed and deltopectoral exposure was performed. Skin, subcutaneous tissue, pectoralis subscapularis, biceps muscles, anterior shoulder capsule and labrum were excised. Anterior-lateral corner of acromion, tips of coracoid and greater tubercle, upper pole of glenoid, lateral epicondyle, and most anterior, medial, superior insertion point of deltoid were marked (Figure 1). At neutral rotation and 20 degree of abduction, humeral head was approximated to glenoid and fixed with 4mm K wire passing from coracoid to humeral head. The distances from greater tubercle to deltoid insertion (GT-D), Anterior- lateral corner of

acromion to deltoid insertion (A-D), coracoid tip to deltoid insertion (C-D), upper pole of glenoid to deltoid insertion (G-D), and humeral length (HL; greater tubercle to lateral epicondyle) were measured. One independent observer measured with a digital caliper while the other observer measured using a tape. Then 5mm thick pegged glenoid trial (Bigliani/Flatow Total shoulder arthroplasty, Zimmer, Warsaw, IN) insert was implanted (Fig. 2), the humerus was then brought to previous position and the coracoid was fixed to the humeral head from the previously drilled holes with a K wire. Measurements were repeated.

Ethical approval: Local ethics committee approval was taken before initiation of the study.

Statistic analysis: The Wilcoxon Signed Rank Test was used to compare the measurements before and after implantation. Statistical significance was set at a P value: 0.05.



Figure 1: Landmarks determined



Figure 2: Trial insert implanted

Table I. Specimen data

	GT-D(digital)	GT-D(manuel)	A-D(digital)	A-D(manuel)	C-D(digital)	C-D(manuel)	G-D(digital)	G-D(manuel)
Left(pre)	140±6	134±12	172±11	165±13	149±12	136±23	158±13	152±16
Left(post)	139±6	133±11	172±14	165±12	148±10	142±21	157±12	153±14
Right(pre)	131±10	143±8	164±11	172±10	136±18	151±14	148±14	155±13
Right(post)	132±10	143±6	163±12	171±9	139±16	155±11	150±16	160±11
Total(pre)	136±9	138±11	168±11	169±12	143±16	144±20	153±14	153±14

## RESULTS

Results are presented at table I. At tape measurement, right shoulder G-D distance was higher at post implant group ( $p<0.04$ ). When all shoulders were compared, C-D was higher at implanted group ( $p<0.04$ ). All other measurements were not different between implanted or not ( $p>.05$ ). Mean length of the arms measured was  $279\pm14$ mm.

## DISCUSSION

Functional limitations and range of motion after reverse shoulder arthroplasty are primarily secondary to a lack of generated muscle force and not due to mechanical limitations [8]. Compared with native anatomy, the deltoid's abduction moment arm in a reverse shoulder has much greater fluctuation peaking at 90 degree of abduction [9]. The results of current studies reported by the literature, the reverse shoulder prosthesis offers many advantages to patients who have advanced shoulder pathology [10,11]. Anterior part of deltoid muscle is vital to functional reverse shoulder arthroplasty [1]. Additionally, partial release of anterior insertion part of the deltoid during plating of the proximal humerus through deltopectoral approach could cause anterior deltoid weakness [2]. Depending on this, it is relevant that a surgeon should keep in mind the distance of anterior deltoid insertion from bony landmarks while doing proximal humerus surgery.

Recently Jobin et al. [7] reported, increased deltoid length that had been measured from X-rays of reverse shoulder arthroplasty patients, correlated with superior active forward elevation. At the particular study's patient X-rays, it was obvious that coracoid to deltoid tuberosity distance seems to be increased [7].

At the present study there was no increase of acromion to deltoid insertion area while there was detectable increase of coracoid tip to deltoid insertion at minimal amount of humeral head lateralization (5 mm) with implantation of 5 mm implant. It is obvious that inferior localization of humeral component relative to glenosphere leads to increase of distance from acromion to deltoid tuberosity at reverse shoulder arthroplasty. However, we did not implant reverse shoulder prosthesis to cadaver bones to verify this. It still seems more clinically relevant to measure the distance from coracoid tip to deltoid insertion instead of acromion since coracoid to deltoid tuberosity is parallel to anterior fibers of deltoid instead of middle fibers originating from acromion and it can detect even small amount of head lateralization due to presence of coracoid tip at the same level with deltoid fibers.

There was no difference when using the digital caliper which was probably due to inaccuracy of placing the arms of caliper at the same level with each other which instead was easily achieved using a measurement tape.

This study is limited by use of formalin fixed cadavers whose muscle length relations might have changed; however, we used bony landmarks that would not change with formalin fixation. Second, we did not implant reverse shoulder prosthesis so that we could not demonstrate increased acromion distance to deltoid insertion; however, at this model we kept arm position constant by fixing head to coracoid that otherwise would change the measurements.

As a conclusion: Deltoid insertion lateralization could be detected from the bony landmarks around the glenoid especially the coracoid tip. Whether this is clinically relevant, further studies need to be carried out.

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**Conflict of interests:** The authors declare that there is no conflict of interests.

**Funding sources:** There is no source of funding or financial interest in this study.

**How to cite this article/Bu makaleye atif için:**

Ozmanevra R, Kaya E. Anterior deltoid insertion distance to various bony landmarks before and after humeral head lateralization. *Acta Med. Alanya* 2019;3(1): 17-20. DOI:10.30565/medalanya.479819