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## Original article

# Mechanical behavior of screw versus Endobutton for coracoid bone-block fixation

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## Abstract

### *Introduction*

Arthroscopic coracoid bone-block fixation by Endobutton was developed to avoid the complications associated with screwing. However, few studies have assessed the mechanical

characteristics of the two. The aim of the present study was to assess and compare fixation rigidity by screw versus Endobutton. The study hypothesis was that rigidity is lower with Endobutton than with screws.

### *Material and Method*

3D print-outs of a glenoid and a coracoid process were obtained from CT scans of a patient showing anterior shoulder instability with significant bone defect. Four types of coracoid fixation were implemented: 1 or 2 4.5 mm malleolar screws, and 1 or 2 Endobuttons. Three specimens per assembly were placed on a specific test bench. Lateromedial bone-block compression was exerted at 0.1 mm/sec at 3 points: superior, central, inferior. The resultant force and bone-block displacement were recorded.

### *Results*

Mean fixation rigidity with 1 screw, 2 screws, 1 Endobutton and 2 Endobuttons was respectively 158 N/mm (range, 133-179), 249 N/mm (241-259), 10 N/mm (5-13) and 14 N/mm (13-15), with significant difference between the screw and Endobutton groups ( $p < 0.001$ ). Displacement was greater with 1 than 2 Endobuttons under superior or inferior force, while the difference was non-significant under central force (7.45 vs 6.93 mm;  $p = 0.53$ )

### *Conclusions*

Screw fixation showed greater rigidity, while the Endobutton assembly showed less tension, leading to greater bone-block mobilization. The interest of using two Endobuttons is to reduce displacement under polar pressure. The present biomechanical study confirmed the mechanical vulnerability of bone-blocks fixed by Endobutton until consolidation is achieved.

Level of evidence: Biomechanical study

Key-words: Latarjet, double-button, Endobutton, bone block, instability, shoulder, biomechanics

## **Introduction**

Athwal et al. [1] reported a 14% complications rate in arthroscopic screw fixation of Latarjet bone-block: coracoid fracture, implantation failure, revision surgery for hardware removal, screw backout. Hardware removal is one reason for surgical revision, with rates up to 10% [2,3]. Endobuttons are relatively recent in orthopedics, but are widely used in a range of indications: acromioclavicular dislocation, anterior cruciate ligament reconstruction, tibiofibular syndesmosis repair, etc. [4,5]. However, no studies have assessed the mechanical characteristics of this procedure in internal fixation of coracoid bone-block. The present study hypothesis was that Endobutton fixation is less rigid than screw fixation. The aim of the study was to compare intrinsic fixation characteristics between Endobuttons and screws.

## **Material and Method**

3D polyactic acid print-outs were made of the scapula from CT reconstruction in a patient operated on for shoulder instability with anterior defect. Coracoid sectioning, anterior glenoid and inferior coracoid resurfacing and the tunnels for fixing the coracoid onto the glenoid were included in the computerized modeling ahead of the 3D printing on Ultimaker 2+®. The anterior glenoid defect was 25%; the bone-block measured 25x12x7 mm; tunnel width was 3 mm for malleolar screwing and 2.8 mm for Endobuttons, in line with the manufacturers' recommendations. The tunnels were 10 mm from the coracoid apex with a 10 mm interval in case of double screw or double Endobutton fixation, and 12 mm from the apex in case of single fixation. A specific base (Instron® 3366) fixed the model onto the test bench by adding a

polyactic acid block on the medial edge of the scapula (**figure 1**). The bone-block was positioned on the anteroinferior edge of the glenoid, subequatorially and flush with the glenoid surface [6].

Coracoid bone-block screw fixation used 2 different assemblies with 1 and 2 non-cannulated cancellous short-threaded 4.5 mm malleolar screws (Malleolar Screw, Depuy Synthes®) [6] (**figure 2**). The bone-block was compressed by subjective pressure on the “2-finger compression” technique [6].

Endobutton fixation followed the technique described by Boileau et al. [7], with 1 or 2 Endobuttons (Smith&Nephew®). 100 N compression was exerted by a dedicated dynamometric tensor (arthroscopic bone-block instrumentation, Smith&Nephew®) (**figure 2**).

Three examples per assembly were printed out and tested. Continuous bone-block compression was exerted lateral-to-medially, simulating humeral head pressure on the bone-block under anteroinferior dislocation, at 0.1 mm/sec at 3 points (superior, central, inferior) (**figure 3**). Resultant force in N and displacement in mm were measured (Bluehill Instron®) on a force/displacement curve. Trials were conducted up to 200 N resultant force or >3 mm displacement.

Descriptive statistics (mean and range for continuous variables) were used to summarize the data. Covariable comparison between the 4 groups (1 or 2 screws, 1 or 2 Endobuttons) used Wilcoxon rank sum test. The significance threshold was set at  $p \leq 0.05$ . Analyses used R software, version 3.3.2 (R Core Team 2013. R Foundation for Statistical Computing, Vienna, Austria).

## **Results**

Mean rigidity with 1 screw, 2 screws, 1 Endobutton and 2 Endobuttons was respectively 158

N/mm (range, 133-179), 249 N/mm (241-259), 10 N/mm (5-13) and 14 N/mm (13-15) (**figure 4**).

Mean displacement under superior, central and inferior pressure are reported for maximal pressures (**Table 1**). One- and 2-Endobutton fixation showed >5 mm displacement for all pressure positions, significantly greater than with screws ( $p < 0.05$ ).

Under central pressure, there was a significant difference between 1- and 2-screw fixation ( $p < 0.05$ ), but not between 1- and 2-Endobutton fixation ( $p > 0.05$ ).

Under superior pressure, displacement differed little between 1- and 2-screw fixation ( $p > 0.05$ ). In contrast, for 1-Endobutton fixation the test could not be performed, due to rotational tilt as of 50 N pressure.

Under inferior pressure, 2-screw fixation showed significantly less displacement than 1-screw fixation ( $p < 0.05$ ), while 1- and 2-Endobutton fixation did not significantly differ ( $p > 0.05$ ).

## **Discussion**

The study objective was to assess coracoid bone-block fixation hardware resistance. Rigidity was greater in fixation by 1 or 2 screws than by Endobutton. One-screw fixation was 15 times more rigid than 1-Endobutton fixation; using 2 Endobuttons did not significantly increase the rigidity.

For 3D printing, we used PLA (polyactic acid) with trabecular architecture simulating bone structure, although intrinsic characteristics obviously differed from bone. On the other hand, composition reproducibility across trials enabled specific assessment of the mechanical assembly, free of the variable and uncontrolled viscoelasticity of classic cadaver bone. Previous studies

comparing coracoid bone-block fixation between types of screw or screw versus Endobutton used fresh specimens, often from elderly donors, introducing inevitable bias [8,9]. Only 1 study, comparing coracoid bone-block fixation between 3 types of screw, used 3D polyurethane printing [10]; some of the reported displacement values may have been due to polyurethane deformation rather than to actual bone-block displacement.

We chose to study only lateromedial displacement, reproducing the stress induced by anterior translation of the humeral head against the bone-block in anterior dislocation. The role of the conjoint tendon was not included, although it may contribute to rotational displacement. Endobuttons are widely used in orthopedic surgery, for acromioclavicular dislocation, distal biceps reinsertion, anterior cruciate ligament reconstruction, distal tibiofibular stabilization, etc. Several studies compared rigidity between Endobuttons and screws, with concordant findings. Brand et al. [5], in a cadaver study, found greater displacement and poorer rigidity in Endobutton fixation of the quadriceps tendon in the femoral tunnel compared to an interference screw for anterior cruciate ligament reconstruction. Wang et al. [4] compared tibiofibular syndesmosis fixation after ankle trauma and found greater displacement with Endobuttons than with screws. And Marsland et al. [11], in a cadaver study comparing metatarsal base fixation after Lisfranc ligament trauma, reported significantly greater intermetatarsal diastasis with Endobuttons than with screws.

In contrast, a recent study by Provencher et al. [12], reported no significant difference between screw or double-Endobutton bone-block fixation under conjoint tendon traction. Their biomechanical model differed from ours, assuming isolated conjoint tendon traction to be able to induce bone-block displacement, with the humeral head immobilized throughout the immediate postoperative period; stress in coracoid bone-block translation and rotation was thus not

analyzed. The present model, on the other hand, simulated the most difficult situation, with a non-consolidated bone-block undergoing direct pressure from a humeral head in anteroinferior dislocation. This rare situation can occur in immediate postoperative dislocation with a non-immobilized shoulder or in case of non-consolidation of the bone-block in later phases. Willemot et al. [10] also compared lateromedial coracoid bone-block displacement between 3 screw diameters in uni- or bi-cortical fixation, and demonstrated the importance of bicortical fixation, regardless of screw diameter.

The theoretic advantage of a second Endobutton would be to improve rotational stability. The present study found that superior pressure induced rotation after 50 N with a single Endobutton. Under inferior pressure, on the other hand, a second Endobutton did not significantly improve stability, with no difference in displacement compared to a single Endobutton.

As well as the issue of secondary displacement, type of fixation can affect bone-block consolidation. Gendre et al. reported a mean fusion rate of 83% on CT at 6 months for arthroscopic Endobutton bone-block fixation [13]. The literature reports 85-100% consolidation for open fixation of Bristow-Latarjet bone-block by 1 or 2 screws [14-17]. These comparable results show that, despite poorer rigidity with Endobutton than screws, the former is nevertheless stable enough to allow bone consolidation.

## **Conclusion**

Internal fixation of a coracoid bone-block by 2 malleolar screws is more rigid than using Endobuttons. Bone-block displacement under lateromedial pressure is significantly greater in



case of Endobutton stabilization. Double Endobutton improves only rotational stability. The present biomechanical study confirmed the mechanical vulnerability of a bone-block fixed by Endobutton until consolidation is achieved.

**Disclosure of interests:** NB is a consultant for Smith&Nephew; VA, JB, PM and PS have no conflicts of interest to disclose in relation to the present article.

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Author contributions:

Nicolas Bonnevalle: study design, data interpretation, article writing.

Vadim Azoulay: study design, data collection and interpretation, figures and article writing.

Pascal Swider: literature review, data interpretation, figures and article writing.

J rome Briot: study design, data collection.

Pierre Mansat: study design, data interpretation, article editing.

All authors approved the final version.

| Type of assembly | Pressure position (200 N)      |                       |                       |
|------------------|--------------------------------|-----------------------|-----------------------|
|                  | Central                        | Superior              | Inferior              |
|                  | Mean displacement (mm) (range) |                       |                       |
| 1 screw          | 1.40<br>(1.32 ; 1.64)          | 1.63<br>(1.31;1.66)   | 2.47<br>(1.86 ; 2.47) |
| 2 screws         | 0.91<br>(0.84 ; 1.04)          | 0.86<br>(0.76 ; 0.96) | 1.19<br>(1.05 ; 1.42) |
| 1 Endobutton     | 7.42<br>(7.35 ; 7.58)          | ND                    | 6.52<br>(4.13 ; 6.69) |
| 2 Endobuttons    | 6.76<br>(6.10 ; 7.93)          | 7.39<br>(4.96 ; 7.43) | 5.24<br>(4.88 ; 5.84) |

**Table 1:** Mean displacement according to assembly type and pressure position.

ND: no data

## **Figure legends**

**Figure 1.** 3D model of glenoid and bone-block

**Figure 2.** Fixation by 1 or 2 screws or 1 or 2 Endobuttons

**Figure 3.** Compression on Instron® test bench

**Figure 4.** Mean rigidity in  $\text{N}\cdot\text{mm}^{-1}$

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