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Biomechanical evaluation of suture buttons versus cortical screws in the Latarjet–Bristow procedure: a fresh-frozen cadavers study

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Abstract

Introduction A commonly used method of fixation of the transferred coracoid in the traditional Latarjet–Bristow procedure (open or arthroscopic) is by two bicortical screws. Although mechanically effective, screw fixation is also a major source of hardware and neurologic complications. This study aimed to compare the biomechanical performances of traditional metal screws and endobuttons as fixators of the Latarjet–Bristow procedure.

Materials and methods Nine fresh-frozen cadaveric human scapulae with the conjoined tendon attached to the coracoid process were used for the Latarjet–Bristow procedure. The specimens were randomly assigned one of two groups: fixation using two 4.5-mm cannulated partially threaded Latarjet–Bristow experience screws or fixation using a suture-button construct. Specimens were secured in a material testing machine and cyclically preconditioned from 2 to 10 N at 0.1 Hz for ten cycles. They were then pulled to failure at a normalized displacement rate of 400% of the measured gauge length per minute. The maximal load-to-failure, stiffness and stress were calculated using a custom script. The failure mechanism and site were recorded for each specimen.

Results There were no significant differences in the maximal load-to-failure or other biomechanical properties of the two fixation techniques, but the failure mechanisms were unique to each one. Four specimens fixated with screws underwent graft failures (fracture) through the proximal or distal drill hole. Five specimens fixated with endobuttons underwent failure due to glenoid bone fractures.

Conclusions A single endobutton fixation appears to be biomechanically comparable to screw fixation in the Latarjet–Bristow procedure and provides a lower risk for graft fracture. Further studies with more numerous specimens are warranted to conclusively validate these findings.

Keywords Shoulder · Latarjet–bristow · Anterior shoulder instability · Glenoid bone loss · Endobutton

Introduction

Shoulder dislocation is the most frequently encountered adult joint instability [1]. There are several surgical modalities for the treatment of this debilitating state, with the Latarjet–Bristow procedure rising in popularity among them [2]. The Latarjet–Bristow procedure involves transferring the coracoid process, attached to the conjoined tendon, and fixating it to the anterior glenoid rim to provide stability [2, 3]. Fixation of the graft to the glenoid is currently being performed through the use of metal screws in a vast majority of the Latarjet–Bristow procedures [4]. The overall reported complications following the Latarjet–Bristow procedure have been widely described in the literature, and they include recurrent instability, neurovascular injuries, infections, graft-related complications (failure of incorporation, fracture, migration, and osteolysis), and hardware-related complications [3, 4].

There is no gold standard method of fixation of the graft during the Latarjet–Bristow procedure, and selection is mainly based on the surgeon's preference [5]. Suture buttons, assorted screw types (e.g., cortical versus cancellous, fully threaded versus partially threaded), and various methods of fixation (e.g., monocortical versus bicortical) have been

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studied as alternative means of coracoid bone graft fixation during the Latarjet–Bristow procedure [6–8]. Suture buttons are not a novel method of soft-tissue fixation in orthopedic surgery. This technique provides an alternative option for anterior cruciate ligament reconstruction, proximal biceps tenodesis, distal biceps repair, pectoralis tendon repair, syndesmotic fixation, and acromioclavicular reconstruction [9].

Although a recently published study by Provencher et al. [4]. compared the biomechanical properties of self-tensioning suture versus metal screws as methods of graft fixation in the Latarjet–Bristow procedure, the published literature in that matter is relatively scarce.

This study compared the biomechanical performance of traditional metal screws with that of endobuttons as fixators during the Latarjet–Bristow procedure. The primary outcome was maximal load-to-failure, and the secondary outcome was the descriptive mode of failure. The study hypothesis was that there would be no significant differences in those outcomes between the two techniques.

Materials and methods

This study was conducted on nine fresh-frozen cadaveric human scapulae with the conjoined tendon attached to the coracoid process. The mean age of the deceased five male and four female donors was 75 years. The specimens were thawed in saline at room temperature for 24 h before dissection. The shoulder joint was dissected free of soft tissue, taking care to preserve the scapulae together with the conjoined tendon attached to the coracoid process The specimens were grossly inspected for signs of glenoid bone and coracoid malformations. Pilot and calibration testing were performed on a sawbones model prior to study initiation (Fig. 1). The shoulders were arbitrarily divided into two similar groups with regard to gender and gross appearance. The first group used two 4.5-mm Latarjet–Bristow experience cannulated screws (DePuy Synthes) as the fixating device. The second group used a double endobutton fixation device (Smith and Nephew).

The study was conducted according to the institutional review board instructions.

Specimen preparation and fixation technique

The shoulders used in this study had been dissected from all the soft tissue, isolating the bony scapulae and its coracoid process attached to the conjoined tendon (the coracobrachialis muscle together with the short head of biceps). An artificial bony Bankart defect of approximately 20% of the glenoid bone surface area was created using an oscillating saw. Starting from the 3 o'clock position, the cut proceeded distally and parallel to the long axis of the glenoid bone. The coracoid process was then osteotomized approximately 20 mm proximal to its tip, leaving the conjoined tendon intact. The inferior aspect of the coracoid graft was decorticated to match the glenoid bone defect.

For the screw fixation group, the graft was first positioned with the use of two 1.5-mm Kirschner wires and then fixed with two 4.5-mm cannulated partially threaded Latarjet–Bristow experience screws. The screws were compressed in a standard two-finger tightness fashion. For the endobutton fixation group, the graft was first drilled bicortically with a 2.8-mm drill for creating a hole through which the anterior four endobutton sutures were passed. Using a designated glenoid bone drill guide, a 2.8-mm

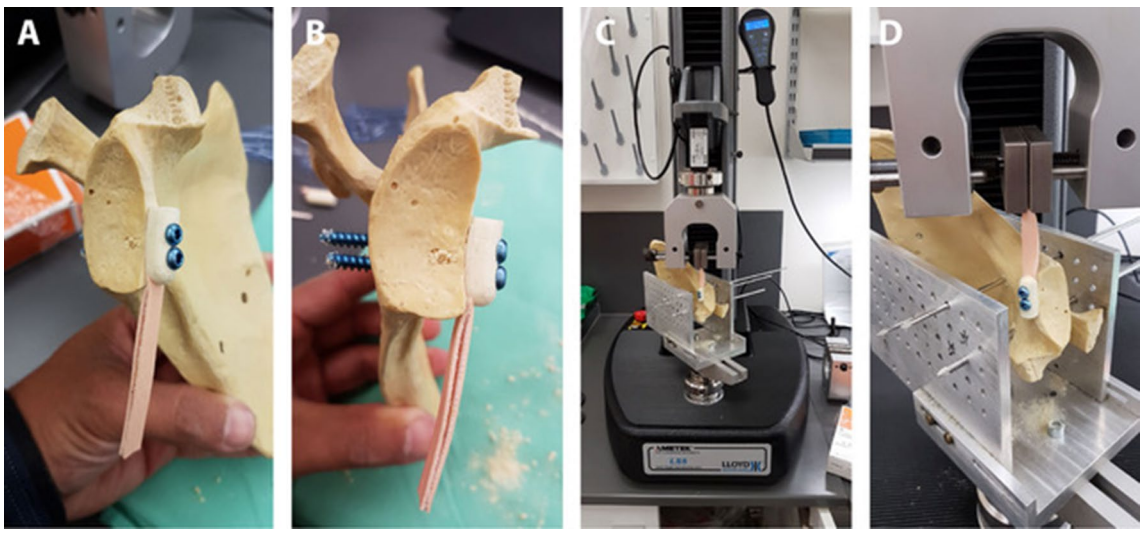

Fig. 1 **a**, **b** Artificial Latarjet–Bristow model with a fixation of two 4.5-mm cannulated partially threaded screws. **c**, **d** Calibration pilot study showing the model placed in the material testing apparatus

hole was drilled in the glenoid bone in a posterior-to-anterior direction. The graft was then positioned on the glenoid defect area, and the four sutures were passed through the glenoid bone and the posterior endobutton with the help of a suture retriever. Compression up to 100 newtons was carried out by a suture tensioner following conformation of the graft positioning graft. The construct was then locked by means of three square knots (Fig. 2).

Biomechanical testing

Biomechanical testing was conducted with a material testing machine (Lloyd LS 5, AMETEK Lloyd Instruments Ltd, UK). The cadaveric scapula was fixated with two 3-mm Kirshner wires into a custom-made frame (Fig. 2). Each specimen underwent the same biomechanical testing protocol as described by Provencher et al. [4]. Briefly, the specimens were cyclically preconditioned from 2 to 10 N at 0.1 Hz for ten cycles. Following preconditioning, the specimens were pulled to failure at a normalized displacement rate of 400% of the measured gauge length per minute. Maximal load-to-failure, stiffness, and stress were calculated using a custom script (NEXYGENPlus™ software). The failure mechanism and site were recorded for each specimen.

Fig. 2 Fresh-frozen cadaveric model mounted in the material testing apparatus

Statistical analysis

Data are presented as mean ± standard deviation. Student's *t* tests were used to assess significance between the groups. SPSS 21 software (IBM Corp) was used for data analysis. Differences were considered statistically significant at $P < 0.05$.

Results

The examined mechanical properties of the two groups did not differ significantly. The average maximal load-to-failure of the endobutton group was 208 N ± 91.5 N, while that of the screw was 216 N ± 53 N ($P = 0.88$) (Fig. 3). The measured average stress at a maximal load in the endobutton group was 1.6 MPa ± 0.70 versus 1.7 MPa ± 0.40 in the screw group ($P = 0.87$). The average stiffness of the endobutton group was 20,427.49 N/m ± 5017.88, whereas that of the screw group was 31,689.52 N/m ± 11,425.84 ($P = 0.141$) (Fig. 3).

Failure mechanism

The two groups differed in their failure mechanisms. Specimens fixated with screws exhibited failure (fracture) of the graft through the proximal or distal drill hole. Four of the five specimens fixated with endobuttons demonstrated failure due to fracture of the glenoid bone. One specimen in the endobutton group failed at the clamp–muscle interference (Fig. 4a–b).

Discussion

The principal findings of this study are that there are no significant differences in the maximal load-to-failure or other biomechanical properties of the two assessed fixation techniques. The failure mechanisms, however, were observed to be unique to each fixation method. The Latarjet–Bristow procedure is gaining greater acceptance in the treatment of patients with recurrent shoulder instability and glenoid bone deficiency. The rate of reported intraoperative and early postoperative complications following the Latarjet–Bristow procedure is relatively high. The reported complications include nonunion, neurovascular damage, screw-related sequelae [3], and screw migration, loosening, and breakage, while implant irritation has been related to joint penetration, soft-tissue impingement, and nerve injury, particularly the suprascapular nerve [6, 8, 10].

Endobuttons have recently been proposed as an alternative method of fixation in the Latarjet–Bristow procedure. Graft fixation with a single cortical button has been

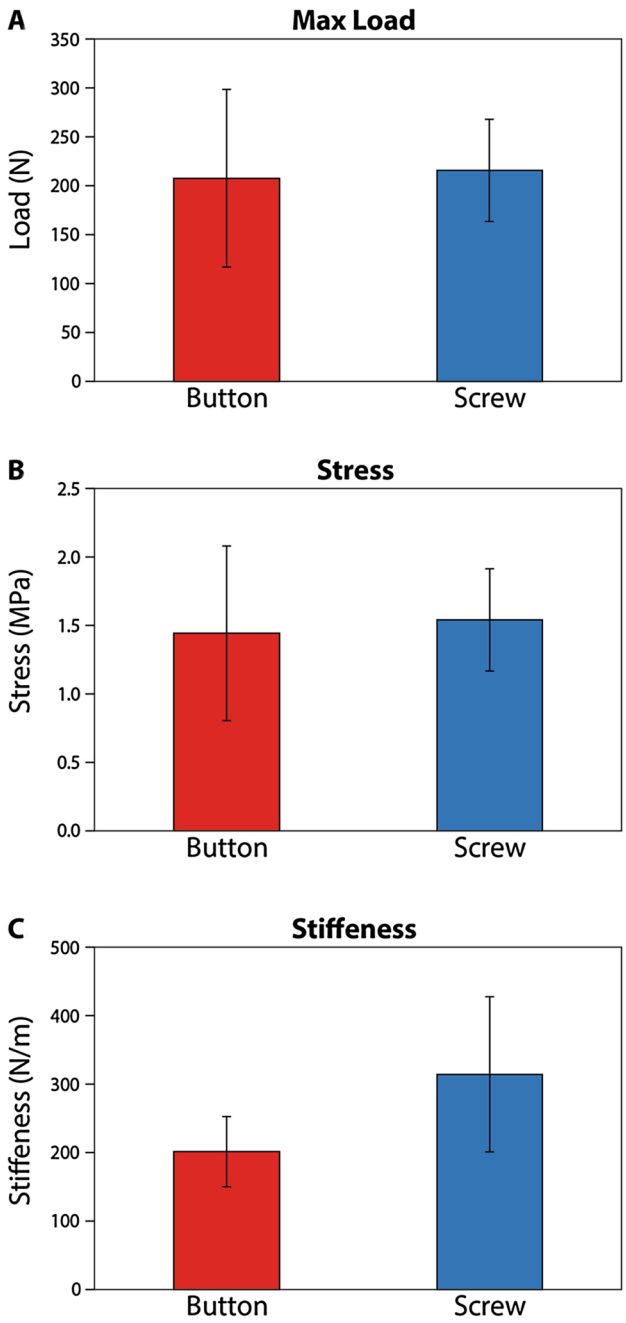

Fig. 3 Biomechanical testing data. The numbers are means (SD)

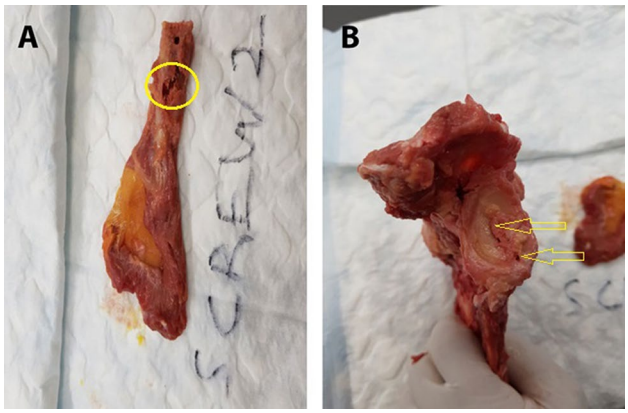

Fig. 4 Failure modes: **a** Screws. **b** Endobutton

suggested as offering a safer method of fixation with no neurological lesions, material breakages, or bone block migration [6]. A more recent study, however, recommended the use of two cortical buttons to achieve superior graft compression and rotational control over the graft [11].

Comparative data on the biomechanical behavior of cortical buttons with screw fixation during the Latarjet–Bristow procedure are scarce. The current study results are in line with those of several recently published biomechanical studies. Namely, Provencher et al. [4] aimed to biomechanically evaluate the ultimate failure load of a cortical button and self-tensioning suture compared to metal screws for coracoid graft fixation during the Latarjet–Bristow procedure. Those authors found no significant difference in ultimate load-to-failure between the screw and suture-button fixation groups. The most common mechanism of failure for the screw fixation method was at the bone block drill holes, while it was an intramuscular rupture that occurred at the clamp–muscle interface for the suture-button construct.

Endobuttons had a higher failure load during cyclic loading than suture anchors transosseous tunnel and interference screws in a distal biceps cadaveric study [12, 13]. Several studies concluded that endobutton fixation had a minimal-to-no displacement because of its being anchored cortically [4, 12–14]. The most common failure mode of the endobutton in the current study was fracture of the posterior glenoid bone, unlike screws that typically fail at the level of the graft holes [13, 15]. One possible explanation for these differences lies in the drilling hole diameters or the lower stiffness of the endobutton construct. A possible advantage of an endobutton fixation is the prevention of graft fracture complications. A recent retrospective clinical study by Boileau et al. [16] reported that suture-button fixation can serve as an alternative to screw fixation for the Latarjet–Bristow procedure by obtaining predictable healing with excellent graft positioning and avoiding hardware-related complications. Those authors concluded that suture-button fixation is simple, safe, and may be used for both open and arthroscopic Latarjet–Bristow procedures.

This study has some limitations inherent in its cadaveric nature. The results obtained from a cadaveric study must be carefully considered, because ex-vivo experiments may not accurately represent in-vivo forces. Bone density was not assessed in this study. The mean age of the tested specimens does not reflect the actual age of the patient population treated for shoulder instability. The number of specimens in

the study was relatively small, therefore precluding our ability to arrive at any significant conclusions. Unfortunately, only the maximum load-to-failure was measured and not the coracoid dislocation after cyclic loading. This would be a potential weakness of a single button fixation compared to two screws. The primary strength of the biomechanical model used in the current study is its resemblance to the procedure performed in patients. This model closely mimics the forces applied through the conjoined tendon in the anatomical settings.

Conclusions

The findings of this study suggest that a single endobutton fixation is biomechanically comparable to screw fixation in the Latarjet–Bristow procedure and that it provides a lower risk for fracture of the graft. Further studies with greater numbers of specimens are warranted to conclusively validate these findings.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval In-vitro biomechanical study.

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