The Bristow and Latarjet Procedures: Why These Techniques Should Not Be Considered Synonymous

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Background: Recurrent shoulder instability is commonly associated with glenoid bone defects. Coracoid transfer procedures, such as the Bristow and Latarjet procedures, are frequently used to address these bone deficiencies. Despite the frequent synonymous labeling of these transfers as the "Bristow-Latarjet" procedure, their true equivalence has not been demonstrated. Therefore, our purpose was to compare the biomechanical effects of these two procedures.

Methods: Eight cadaveric specimens were tested on a custom shoulder simulator capable of loading nine muscle groups and of accurately orienting the joint throughout shoulder motion. The specimens were tested in the intact state, following Bristow and Latarjet reconstructions of a capsulolabral injury (0% glenoid defect), and following each procedure after creation of 15% and 30% glenoid bone defects. The reconstruction order was randomized. In each condition, joint stiffness (anterior stability) and occurrence of dislocation were assessed in shoulder adduction and abduction with neutral and external rotation.

Results: No significant differences (p < 0.05) in joint stiffness or stability were found between the Bristow and Latarjet reconstructions for the 0% glenoid defect in any joint position. However, substantially greater joint stiffness occurred following the Latarjet procedure, as compared with the Bristow procedure, for the 15% and 30% glenoid bone-loss conditions in adduction with neutral rotation, adduction with external rotation, and abduction with external rotation (average across the three joint positions: 8.6 ± 4.4 N/mm versus 3.9 ± 1.26 N/mm [p = 0.034] with 15% bone loss and 7.5 ± 4.4 N/mm versus 3.4 ± 1.5 N/mm [p = 0.045] with 30% bone loss). The Latarjet reconstruction restored the stiffness that had been measured in the intact state in eleven of the twelve tested conditions, whereas the Bristow procedure was successful in only four of the twelve conditions. In addition, during instability testing, three more specimens dislocated following the Bristow reconstruction, compared with the Latarjet procedure, in the 15% defect condition and five more dislocated in the 30% defect condition.

Conclusions: The Bristow and Latarjet procedures are not equivalent in terms of their effects on glenohumeral joint stiffness and stability in cases of glenoid osseous deficiency.

Clinical Relevance: The Bristow and Latarjet procedures have equivalent stabilizing effects in unstable shoulders with preserved glenoid osseous anatomy. However, the Latarjet procedure confers superior stabilization in the setting of substantial glenoid bone loss.

Selecting the optimal surgical treatment for patients with recurrent anterior shoulder instability and associated glenoid bone deficiency poses a complex problem. This is especially true when this deficiency involves a substantial portion of the glenoid width because, in these cases, isolated soft-tissue repairs have exhibited failure rates as high as 56% to 67%1–3. Itoi et al. found that, with defects as small as 21% of the glenoid width, significantly less translational force was required to produce humeral head subluxation and recommended osseous reconstruction. Various techniques have been proposed for
glenoid reconstruction, including iliac crest autograft, allograft, and coracoid transfer. An investigation by Wellmann et al. and our previous study have shown that coracoid transfer procedures biomechanically outperform other reconstructive options as a result of the additive dynamic stabilizing “sling” effect produced by the repositioned conjoint tendon. These findings support the premise that coracoid transfer is a good option for instability-related glenoid defects, with some authors proposing its use even for the treatment of isolated capsulolabral tears.

Multiple techniques for coracoid transfer have been described, with the most common being the Bristow and Latarjet procedures. There is little consensus about which of these two techniques is optimal. The Bristow procedure transfers only the tip of the coracoid, such that the resected surface is in contact with the glenoid vault. The Latarjet procedure transfers the entire horizontal pillar, such that the inferior surface of the coracoid is in contact with the vault (Fig. 1). Despite their frequent synonymous labeling as “Bristow-Latarjet” coracoid transfer, they represent distinct reconstructive procedures whose true equivalence has not been demonstrated. The purpose of this study was to compare the stabilization effects of these two procedures for progressive levels of anterior instability (isolated capsulolabral injury, and 15% and 30% glenoid deficiency). We hypothesized that the smaller coracoid fragment used with the Bristow procedure would result in less stabilization than that provided by the Latarjet reconstruction and that the differential would become more notable with increasing glenoid deficiency.

Materials and Methods

Specimen Preparation and Shoulder Simulator

Eight fresh-frozen cadaveric shoulders from donors with a mean age (and standard deviation) of 74 ± 11 years at the time of death were tested after being screened for rotator cuff deficiency, osteoarthritis, and prior surgery. Following transection at the midpoint of the humerus, shoulder dissection was performed to identify the deltoid muscle, rotator cuff muscles, short and long heads of the biceps, and glenohumeral joint capsule. We employed a custom shoulder simulator (Fig. 2) that could (1) load all relevant shoulder muscles, (2) repeatedly orient the scapula and glenohumeral joint, and (3) record the loads applied during testing and the resulting motions. Additional details about the simulator and experimental setup are in the Appendix.

Experimental Testing Protocol

The protocol was designed to compare the effects of the Bristow and Latarjet procedures on joint stiffness, stability, and range of motion when they were used to treat isolated capsulolabral injuries as well as 15% and 30% osseous glenoid defects. In order to achieve the repeated joint access required in this repeated-measures study, we utilized an extended lesser-tuberosity osteotomy, the site of which was then fixed with two 1/8-in (3.2-mm) bicortical nut-and-bolt constructs. Previous investigations had demonstrated that this osteotomy had no biomechanical effect.

Seven conditions were tested: intact, Bristow and Latarjet coracoid transfers with an isolated capsulolabral injury (intact glenoid), and Bristow and Latarjet coracoid transfers following creation of 15% and 30% anterior glenoid bone defects. The anterior capsulolabral injury was created by releasing the anteroinferior aspect of the glenoid labrum away from the glenoid rim and sectioning the capsule from the humeral neck to the inferior glenoid pole. Glenohumeral instability was ensured by propagating the injury through forcible dislocation in the anteroinferior direction.

The 15% and 30% bone defects were created according to the description by Saito et al., who found that the average defect is located close to the three o’clock position. The technique for simulating glenoid defects described by Yamamoto et al. was also utilized. The maximum anteroposterior glenoid width was measured with digital calipers, after which the defect was created by cutting with a microsagittal saw along a line perpendicular to the anteroposterior direction for 15% or 30% of the glenoid width.

Following creation of the isolated capsulolabral tear and each bone defect, a coracoid transfer was performed and tested. The initial reconstruction was then removed and the second transfer was performed. The order of the reconstructions was randomized and balanced between the two procedures. The Bristow reconstruction was performed as originally described, whereas the Latarjet was performed as described by Walch and Boileau. Both reconstructions required structural stabilization using bicortical 10 mm screws. The reconstruction was performed as described by Walch and Boileau. Both reconstructions required structural stabilization using bicortical 10 mm screws.

Fig. 1
Computer renderings of the Bristow (left image) and Latarjet (right image) coracoid transfers for a 15% and 30% anterior glenoid bone defect, respectively. Note that each of these renderings illustrates reconstruction of only one defect size; however, the graft size and orientation for both reconstructions were consistent across the three tested defect sizes (0% [isolated capsulolabral injury] and 15% and 30% glenoid defects).
the transfer of a segment of the coracoid with the attached conjoint tendon; however, different graft sizes were required. Therefore, in order to test both reconstructions in random order and at multiple defect levels, a size-matched coracoid with an attached conjoint tendon was harvested from a fresh-frozen donor for each specimen tested. The reconstruction done with this harvested coracoid was selected with use of a balanced randomization procedure to ensure that equal numbers of Bristow and Latarjet reconstructions were performed with use of the size-matched donor. For the Bristow reconstruction, the coracoid tip was osteotomized 10 mm from its end and, along with the attached conjoint tendon, was transferred through a horizontal subscapularis split to the anterior aspect of the glenoid. The subscapularis split was created between the upper two-thirds and lower one-third of the tendon. The osteotomized surface of the coracoid tip was then rigidly fixed to the glenoid vault with use of a single 3.75-mm bicortical screw inserted along the graft’s long axis (Fig. 1). For the Latarjet reconstruction, the coracoid process was osteotomized at its angle, or elbow, and transferred with the conjoint tendon to the anterior aspect of the glenoid through the same subscapularis split. The inferior surface of the coracoid was decorticated and fixed to the anterior aspect of the glenoid with use of two 3.75-mm bicortical screws (Fig. 1). The coracoid was removed following testing of each reconstruction to allow the other reconstruction to be implemented and tested, or to create the next defect level. Because repeated fixation to the glenoid vault was required, care was taken to utilize the same holes for each reconstruction, with bicortical purchase obtained through the posterior cortex of the glenoid neck. No loss of coracoid fixation was observed at any time during testing.

During testing, the conjoint tendon was loaded to replicate the dynamic “sling” effect. The tendon was loaded by suturing the proximal musculotendinous junction and replicating its natural line of action before connecting it to a miniature pneumatic actuator (Bimba Manufacturing, University Park, Illinois) mounted on the simulator. The simulator is capable of physiologically orienting the scapula and glenohumeral joint in four degrees of freedom. The simulator consists of the following components: A = potted scapular specimen (with soft tissues omitted for clarity); B = humerus (with soft tissues omitted for clarity); C = computer-controlled scapular elevation mechanism, which achieves repeatable positioning; D = glenohumeral abduction guide arc and slider; E = glenohumeral plane-of-elevation adjustment plate; F = low-friction deltoid and rotator cuff guide system, which routes the cables to the pneumatic actuators; G = six-degrees-of-freedom tracking markers; H = cemented humeral rod with interposed six-degrees-of-freedom load cell; and I = miniature pneumatic actuators used to separately load the long head of the biceps and the conjoint group.

| TABLE I Glenohumeral Dislocation During Two Stability Tests |
|------------------|------------------|------------------|
|                  | Clinical Drawer Test |                |
|                  | 0% Defect | 15% Defect | 30% Defect |
| Bristow          | 0         | 6          | 4          |
| Latarjet         | 0         | 1          | 1          |
|                  | Extension* |               |
|                  | 0% Defect | 15% Defect | 30% Defect |
| Bristow          | 0         | 4          | 6          |
| Latarjet         | 0         | 1          | 1          |

*Passive extension of the humerus from an initial position of abduction with external rotation in the scapular plane.
to the humerus (Fig. 2)\(^4\). Throughout the range of motion, the tendon was tensioned to 10 N\(^{\circ}\).

**Stability and Range of Motion**

Stability and range of motion were assessed with the glenohumeral joint in adduction (0° of abduction in the scapular plane) and in abduction (60° of glenohumeral abduction in the scapular plane with 30° of scapulothoracic elevation). Stability was quantified on the basis of glenohumeral joint stiffness (N/mm) and whether the humeral head dislocated. Stiffness was calculated by passively applying an anteroinferiorly directed quasi-static load and dividing it by the magnitude of humeral translation relative to the glenoid (Fig. 3). Seventy newtons was chosen as the maximum load on the basis of pilot testing by an experienced shoulder surgeon (G.S.A.) performing a standard drawer test.

Maximum humeral translation was defined as the magnitude of displacement at the time of glenohumeral dislocation or, if dislocation did not occur, at the time of maximum force application. Occurrence of dislocation (defined by the apex of the humeral head passing over the intact or reconstructed glenoid rim) was assessed visually and confirmed optoelectronically. Stiffness was evaluated at the time of maximum force application. Joint dislocation (yes or no), whereas range of motion was reported in degrees.

**Outcome Variables and Statistical Analyses**

Stability was quantified in terms of glenohumeral joint stiffness (N/mm) and joint dislocation (yes or no), whereas range of motion was reported in degrees. The value for internal-external rotation represented the rotation from the position of maximum internal rotation to the position of maximal external rotation. The range of horizontal extension was quantified as the magnitude of humeral rotation about the scapula's superior axis posterior to the scapular plane. A two-way repeated-measures analysis of variance (ANOVA) was performed for each parametric outcome variable. Whenever an interaction effect was exhibited, follow-up post-hoc tests were performed. For full details of the statistical analyses, see the Appendix.

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**Results**

**Joint Stiffness and Stability**

Comparing the Bristow and Latarjet procedures across the three defect levels by using a two-way repeated-measures ANOVA demonstrated no interaction effects between the reconstruction technique and defect size (p ≥ 0.189), except with the arm in adduction with neutral rotation (p = 0.014). In that case, post-hoc tests demonstrated that the Bristow procedure resulted in significantly less stiffness than the Latarjet procedure when it was used for the 15% and 30% defects (mean and standard deviation, 5.1 ± 1.3 N/mm versus 9.8 ± 3.2 N/mm [p = 0.004] and 4.4 ± 1.8 N/mm versus 10.0 ± 6.4 N/mm [p = 0.021], respectively) but not when it was used for the 0% defect (5.4 ± 1.4 N/mm versus 7.4 ± 3.3 N/mm [p = 0.156]). The main effect of reconstruction type was significant for all joint configurations, with the Latarjet procedure resulting in significantly greater stiffness than the Bristow procedure across all three glenoid defect levels (average across the three defect levels, 5.0 ± 1.1 N/mm versus 9.0 ± 4.1 N/mm in adduction with neutral rotation [p = 0.018], 4.0 ± 1.3 N/mm versus 9.0 ± 4.6 N/mm in adduction with external rotation [p = 0.007], 3.3 ± 1.0 N/mm versus 5.2 ± 1.2 N/mm in abduction with neutral rotation [p = 0.012], and 2.7 ± 0.9 N/mm versus 4.6 ± 1.7 N/mm in abduction with external rotation [p = 0.003]).
Subsequent one-way repeated-measures ANOVA for each joint configuration at each of the three defect levels (Figs. 4 and 5) further illustrated the significance of the above trends. The Bristow reconstruction resulted in joint stiffness values that were consistently lower than those in the intact condition or after the Latarjet procedure. The decreases in stiffness after the Bristow procedure, compared with the stiffness in the intact shoulder, were significant at all defect levels with the joint in adduction with neutral rotation and in adduction with external rotation (all comparisons at both joint positions for the three defect levels had p values of <0.040) and were significant for the 15% defect condition (2.6 ± 1.5 N/mm [p = 0.002]) and the 30% defect condition (2.3 ± 0.8 N/mm [p = 0.001]) with the shoulder in abduction and external rotation (intact: 4.8 ± 1.3 N/mm).

Fig. 4
Anterior glenohumeral joint stiffness with the arm in adduction (Add) and neutral (NR) or external (ER) rotation in the intact state and after the Bristow (B) and Latarjet (L) reconstructions. Any testing state marked with an asterisk represents a significant difference compared with the intact state as demonstrated by one-way repeated-measures ANOVA.

Fig. 5
Anterior glenohumeral joint stiffness with the arm in abduction (Abd) and neutral (NR) or external (ER) rotation in the intact state and after the Bristow (B) and Latarjet (L) reconstructions. Any testing state marked with an asterisk represents a significant difference compared with the intact state as demonstrated by one-way repeated-measures ANOVA.
In contrast, the Latarjet procedure achieved stiffness values generally similar to those in the intact condition, with a significant difference only in adduction with neutral rotation following reconstruction of a 0% defect (7.4 ± 3.2 N/mm versus 11.3 ± 4.5 N/mm in the intact condition [p = 0.026]). The joint stiffness following the Latarjet procedure was significantly greater than that after the Bristow procedure in the 15% defect condition when the measurements were made in adduction with neutral rotation (p = 0.012) and in the 15% (p = 0.026) and 30% (p = 0.017) defect conditions when they were made in abduction with external rotation (Figs. 4 and 5). The Latarjet procedure, compared with the Bristow procedure, resulted in an increase in stiffness that approached but did not reach significance in the 30% defect condition in adduction with neutral rotation (p = 0.062) and in the 15% (p = 0.064) and 30% (p = 0.056) defect conditions in adduction with external rotation.

During passive horizontal extension testing in the position of apprehension, a dislocation occurred in four of the eight and six of the eight specimens treated with the Bristow procedure for 15% and 30% defects, respectively. With the Latarjet procedure, however, there was only one dislocation at each defect level (Table I). During testing in abduction with external rotation, a dislocation occurred in six of the eight specimens treated with the Bristow procedure for a 15% defect and in four of the eight treated with the Bristow procedure for a 30% defect; the Latarjet procedure again allowed only one dislocation at each defect level.

### Range of Motion

Two-way repeated-measures ANOVA for range of motion in adduction and abduction indicated no interaction effects between the reconstruction technique and defect size (p ≥ 0.333). There were no significant main effects on the range of internal-external rotation during adduction across the reconstruction types (p = 0.721) or defect levels (p = 0.288). There were no significant main effects on the range of internal-external rotation in abduction for either reconstruction across all testing conditions (reconstruction type: p = 0.452, defect size: p = 0.576). However, one-way repeated-measures ANOVA of the range of internal-external rotation in abduction demonstrated significant differences between the two reconstructions and between each of the reconstructions and the intact state (Fig. 6). Specifically, both the Bristow procedure and the Latarjet procedure significantly reduced the range of motion compared with that in the intact condition across the three defect levels, with the Bristow procedure resulting in 52.4° ± 12.8° of motion when it...
was performed for the 0° defect (p = 0.0280 for the comparison with the intact state [65.0° ± 13.3°]), 44.4° ± 21.3° after reconstruction of the 15% defect (p = 0.045), and 47.2° ± 10.7° after reconstruction of the 30% defect (p = 0.001) and the Latarjet procedure resulting in 44.8° ± 14.2° when it was performed for the 0° defect (p = 0.003), 45.1° ± 10.1° after reconstruction of the 15% defect (p = 0.008), and 45.1° ± 10.1° after reconstruction of the 30% defect (p = 0.033). In contrast, only the 0% defect produced a significant difference between the two reconstructions (Bristow: 52.4° ± 12.8° versus Latarjet: 44.8° ± 14.2° [p = 0.033]) with the arm in abduction.

During horizontal extension with the arm in abduction and external rotation, there was no significant interaction effect or main effect in range of motion for either reconstruction type (p = 0.355) or defect level (p = 0.298). One-way repeated-measures ANOVA showed no differences between either reconstruction and the intact state at any defect level (Fig. 6).

**Discussion**

In the present experimental setting, in all joint configurations and with any glenoid defect, the Latarjet procedure achieved between 30% and 90% higher stiffness than the Bristow procedure. Additionally, the Bristow procedure achieved only 27% to 99% of the intact-condition stiffness, whereas the Latarjet procedure restored stiffness to within 17% of that in the intact specimen under most conditions. Compared with the stiffness in the intact specimen, the stiffness deficit following the Bristow procedure was significant in eight of the twelve testing conditions, whereas the deficit following the Latarjet procedure was significant in only one testing condition. In addition, the Latarjet procedure substantially outperformed the Bristow procedure in six of the twelve comparisons of the stiffness achieved by the two techniques and this difference was statistically significant in three of these conditions. Abduction with neutral rotation was the only joint configuration at which there was no substantial difference for any defect level. These findings indicate that the Latarjet procedure consistently outperformed the Bristow procedure in terms of restoring joint stiffness and that the stiffness differential between the two techniques increased with increasing anterior glenoid bone deficiency. Finally, in all shoulder configurations, stiffness following the Latarjet reconstruction actually increased between the 0% and 15% defects; it increased between the 15% and 30% defects in two of the four joint configurations. We believe that this non-intuitive result can be attributed to the progressively posterior positioning of the conjoint tendon origin on the coracoid tip as the graft was fixed to sequentially larger defects. This posterior translation of the tendon origin in turn may have caused the tendon to wrap under the humeral head more completely, strengthening the dynamic sling effect proposed by May21 and biomechanically confirmed in previous studies22. This progressive stiffening effect, however, was not observed with the Bristow procedure.

When used for an isolated capsulolabral injury without glenoid bone loss, the Bristow procedure and the Latarjet procedure were equivalent in their ability to prevent dislocation. However, when used for glenoid bone loss, the Latarjet reconstruction resulted in only one dislocation at each defect level (15% and 30%) during each instability test (drawer test and horizontal extension), whereas the Bristow procedure resulted in dislocation in four or six of the specimens at each defect level.

Testing of internal-external rotation range of motion in adduction showed the effects of the Bristow and Latarjet procedures to vary between defect levels, with no trends evident and with no differences compared with the intact condition. In contrast, the effects of the two reconstructions were quite consistent across all conditions during testing of the range of motion in abduction, with a significant reduction in the internal-external rotation arc compared with that in the intact state (range of decreases, 17.8° ± 2.8° to 20.6° ± 6.4° [0.001 ≤ p ≤ 0.045]) except when the Bristow procedure was performed for an isolated capsulolabral injury (12.5° ± 3.5° [p = 0.028]). In addition, the Latarjet procedure resulted in a significantly smaller range of motion than the Bristow procedure when the reconstructions were used for an isolated capsulolabral injury (44.8° ± 14.2° versus 52.4° ± 12.8°, p = 0.033), but the effects of the two procedures were equivalent for both osseous defects tested. Neither reconstruction caused a significant change in horizontal extension range of motion.

The present results are in agreement with those of Wellmann et al. with regard to the stabilizing effect of the Latarjet procedure in both neutral and external rotation21. However, Wellmann et al. did not assess range of motion. The current results for the Latarjet reconstruction are also in agreement with our group’s earlier results for two technical variants of the Latarjet reconstruction22. To our knowledge, the previous literature on the biomechanical effect of the Bristow procedure is limited to the study by Wellmann et al., which involved transfer of a coracoid-tip graft of a size similar to that utilized in the Bristow procedure in our study, but the graft itself was oriented in the manner used in the traditional Latarjet procedure21. With this “pseudo-Bristow” coracoid transfer, Wellmann et al. found increased glenohumeral translations compared with those following their Latarjet reconstructions, an observation that also agrees with the present finding of reduced glenohumeral stiffness.

One limitation of our study is that time-zero cadaveric testing cannot account for healing effects or soft-tissue relaxation. The use of size-matched donor coracoid grafts with the attached conjoint tendon is also a potential limitation, in that the donor graft may not have exactly matched the coracoid of the recipient. However, the use of size-matched grafts was randomized and balanced between specimens and thus any differences should have affected both reconstructions equally. The use of successive glenoid defects precluded testing of the unrepaired state at each defect level, as the coracoid was removed from the specimen at the first defect level. However, since the primary goal of the study was to compare the reconstructions with the intact specimen and with each other, study of unrepaired defects was not imperative.

This investigation has demonstrated that Bristow and Latarjet coracoid transfers are not biomechanically equivalent and should not be considered interchangeable for treating anterior shoulder instability. Latarjet coracoid transfer has a
greater ability to restore glenohumeral joint stability. This restoration of stiffness will seemingly help normalize joint kinematics and kinetics by maintaining the joint in a well-reduced configuration, thus preventing excessive coracoid-graft loading. Evaluation of the effects on range of motion demonstrated that axial rotation in abduction was significantly limited by both reconstructions. Although such restriction is undesirable from a patient-satisfaction point of view, it may prevent the joint from reaching the position of apprehension, which could cause a (propricceptive) perception of instability despite an actual improvement in stability. However, the Bristow procedure restricted motion without restoring intact joint stiffness. Thus, the Bristow procedure has the disadvantages of the Latarjet procedure—motion restriction—without its benefits—joint stabilization. Additional studies are required to determine if this restriction is clinically relevant and whether it persists over time or decreases with soft-tissue attenuation.

In conclusion, the Bristow and Latarjet procedures are essentially equivalent in their ability to stabilize a shoulder with anterior instability and an intact glenoid. However, the Latarjet procedure restricts rotational range of motion to a significantly greater extent, indicating that the Bristow procedure may be the preferred coracoid transfer for isolated capsulolabral injuries. In the setting of substantial glenoid osseous deficiency, however, the Latarjet reconstruction is superior to the Bristow procedure in its ability to restore joint stability. Therefore, in terms of its biomechanical efficacy, the Latarjet procedure may be a preferable treatment option among coracoid transfer procedures.

Appendix
Details of the experimental setup and statistical analyses are available with the online version of this article as a data supplement at jbjs.org.

References