Editorial Commentary: Shoulder Superior Capsular Reconstruction Graft Tensioning Between 30° and 40° of Glenohumeral Abduction Is Recommended: The Balance Beam of Superior Capsular Reconstruction

Michael J. Foster, M.D., Jared A. Hanson, B.A., and Peter J. Millett, M.D., M.Sc.

Abstract: Massive irreparable rotator cuff tears in young, active patients pose a challenging treatment dilemma. Since the relatively recent development of the superior capsular reconstruction (SCR) procedure, the technique has been increasingly used to stave off reverse total shoulder arthroplasty in this demographic. As a result of continued output of supportive literature, both biomechanically and clinically, SCR has been adopted by surgeons despite some technical aspects of the procedure not being fully elucidated. One notable topic of study is the ideal glenohumeral position in which to determine graft length and therefore graft tension. Tensioning inevitably affects glenohumeral joint kinematics, including superior humeral head translation, subacromial contact pressure, and graft healing potential. Although it is currently known that some degree of glenohumeral abduction is necessary for appropriate graft tensioning, and there are some biomechanical studies from our group and other groups that have looked at this, there is not a clinically supported position in which to measure graft length and therefore set graft tension. Well-designed biomechanical studies will serve as the foundation for what is performed clinically. On the basis of the best available evidence, tensioning the graft between 30° and 40° of glenohumeral abduction is recommended and has yielded encouraging clinical outcomes for SCR in our patients.

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Massive irreparable rotator cuff tears remain a challenge to treat, especially in the young, active population. Although various treatment options exist, superior capsular reconstruction (SCR) is a viable procedure for irreparable posterosuperior rotator cuff tears, showing improved clinical outcomes in short- and mid-term studies.[1-4] Although Mihata et al.[3] originally described reconstruction of the superior capsule using a fascia lata autograft, the procedure has continued to evolve, with increasing use of acellular human dermal allograft to avoid donor-site morbidity and to reduce surgical time. A number of studies have shown successful clinical outcomes using SCR,[1,4-6] including our own series by Petri et al.,[7] Lacheta et al.,[8] and Ciccotti et al.[9] Despite good clinical outcomes, questions regarding several technical aspects of the procedure still exist, including the ideal graft tension for optimal clinical outcomes.

We commend Tibone, Mansfield, Kantor, Giordano, Lin, Itami, McGarry, Adamson, and Lee[10] for reporting on the biomechanical effects of determining graft length for SCR with human dermal allograft at 20° and

Vail, Colorado

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40° of glenohumeral abduction. In "Human Dermal Allograft Superior Capsule Reconstruction With Graft Length Determined at Glenohumeral Abduction Angles of 20° and 40° Decreases Joint Translation and Subacromial Pressure Without Compromising Range of Motion: A Cadaveric Biomechanical Study," Tibone et al. showed that by determining graft length—and therefore tension—at 20° and 40° of glenohumeral abduction, there was a reduction in superior humeral translation and subacromial contact pressure without compromising range of motion. It is noteworthy that graft fixation at 40° compared with 20° of glenohumeral abduction resulted in significantly less superior translation when the shoulder was loaded in 0° of abduction; however, this still did not restore the intact state.[10] Regarding subacromial contact pressure, fixation at both 20° and 40° of glenohumeral abduction restored pressures to the intact state, but fixation at 40° reduced contact pressure to a greater degree.[10]

The article by Tibone et al.[10] suggests that fixation of the human dermal allograft under greater tension restores more normal glenohumeral joint kinematics, but the question then arises whether it is possible that fixation at a certain glenohumeral abduction angle could apply too much tension, resulting in either mechanical failure or failure of healing. When one is performing an SCR, there are 2 mechanisms that can provide superior glenohumeral joint stability: a tenodesis effect and a subacromial spacer effect.[11] When Mihata et al.[12] investigated the effect of fascia lata graft thickness and tension on glenohumeral joint stability, they found that an 8-mm graft provided greater stability than a 4-mm graft and found that superior shoulder stability was normalized when the graft was attached between 10° and 30° of glenohumeral abduction. Although a thicker fascia lata autograft may be able to provide a tenodesis and a spacer effect, human dermal allografts tend to be between 3 and 4 mm thick and thus rely more on the tenodesis effect to create a stable fulcrum during early ranges of glenohumeral abduction.[11] Although some surgeons may generalize from the findings of Mihata et al.[12] that all grafts should be tensioned between 10° and 30° of glenohumeral abduction, in our opinion, it is important to recognize that fascia lata and dermal grafts have different biomaterial properties, with dermal allografts having a lower modulus of elasticity[13]; therefore, tensioning effects and arm positioning to achieve that tensioning may be different across grafts. When Mihata et al.[14] compared SCR using fascia lata allograft versus human dermal allograft, the human dermal allografts elongated by 15% during testing whereas the fascia lata allograft lengths remained unchanged.

Undoubtedly, we agree with the findings suggested in the current work by Tibone et al.[10] that human dermal allografts need to be measured and fixated at appropriate glenohumeral abduction angles to restore more normal glenohumeral mechanics. However, as the authors acknowledge as the major limitation of their investigation, it is quite difficult to translate the findings of a static time-zero biomechanical study to clinical practice, in which a multitude of potential biological and dynamic factors impact outcomes. Ultimately, little clinical evidence exists on the balance between SCR graft tension and graft healing, although most clinical studies have shown higher functional outcome scores in patients with graft healing versus graft failure.[1,8] We do know that SCR grafts can heal solidly to the glenoid and tuberosity as shown by Altintas et al.[15] Thus, when performing SCR, we consider patient factors such as bone quality as well as the elasticity of the dermal allograft when determining at what glenohumeral abduction angle to measure and fixate the graft.[16,17]

In addition to arm position, surgical technique likely contributes to initial graft tension. All sutures can be passed through the graft outside the body, in which case the tension is determined by where the sutures are passed through the graft and how that relates to the distances between the actual bony fixation points. Alternatively, the sutures can be passed through the graft after the graft is inserted and the arm position is adjusted accordingly, effectively tailoring the tension once the graft has been positioned in the shoulder. We prefer the latter technique because it allows us to dial in the tension by inserting the graft into the shoulder, fixating it medially, setting the arm abduction angle, pulling on the graft to determine the tension, and then fixating the graft laterally with a double-row, self-reinforcing tape bridging construct. For most patients, we tension the graft with the arm position set between 30° and 40° of glenohumeral abduction and furthermore routinely repair the graft to the upper border of the subscapularis and the remaining infraspinatus or teres minor to restore glenohumeral force couples. Using this approach, Lacheta et al.[18] from our laboratory showed in a dynamic robotic shoulder model that SCR reduced superior translation of the humeral head at all abduction angles and returned the humeral head to its native position at 60° and 90° under static testing conditions. Clinically, we have reported significant preoperative to postoperative improvement in clinical outcomes (American Shoulder and Elbow Surgeons score, 54.0 preoperatively vs 83.9 postoperatively; $P < .001$).[2] Furthermore, in a series of patients who underwent SCR performed by the senior author, we have shown a high survivorship rate of 95.5% at minimum follow-up of 2 years.[2,8] By taking a patient-specific approach, we attempt to balance our restoration of glenohumeral mechanics while maintaining a high graft healing rate. In conclusion, we believe proper tensioning of the human dermal allograft when performing SCR is of great importance, and by considering what we have learned from biomechanical studies thus

far, further clinical studies can help determine the ideal graft tension to optimize patient outcomes.

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