The “Safe Zone” Technique Improves Suture Placement and Accuracy During Arthroscopic Remplissage

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abstract

In response to recent concerns about the accuracy of suture passage during arthroscopic remplissage, this study was conducted to determine whether a previously described “safe zone” technique can improve the accuracy of suture passage. A recommended safe zone technique was used for arthroscopic remplissage on 6 cadaveric specimens. The safe zone was described as a region at least 1 cm lateral and no greater than 3 cm distal to the posterolateral acromion. Results were compared with a control group of 6 specimens for which the safe zone technique was not used. For each group, 24 suture passes were performed. In the safe zone group, 83.3% (20 of 24) of sutures passed through the infraspinatus tendon. This was a significant improvement compared with the control group, in which only 25% (6 of 24) of sutures pierced the infraspinatus tendon (P<.01). In the safe zone group, 4.2% (1 of 24) of attempted suture passes were placed through the muscle or musculotendinous junction compared with 75% (18 of 24) in the control group (P<.01). Prevention of overmedialization improved significantly with the safe zone technique. In the safe zone group, both anchors had significantly more lateral (6 to 10 mm) suture passage compared with the control group (P<.01). The safe zone technique also showed greater precision of suture passages, and overall precision (SD) improved in 75% of passes. The safe zone technique significantly improved the accuracy of suture penetration into the infraspinatus tendon during arthroscopic remplissage. This reproducible method may help to prevent the reported complications of remplissage. [Orthopedics. 2017; 40(4):e598-e603.]

Hill-Sachs lesions can be difficult to treat and are commonly found in cases of recurrent instability.1-3 Recent data showed that the depth of the defect matters less than its orientation, width, and subsequent association with the glenoid track as the arm abducts and rotates externally.4 This engagement between the Hill-Sachs lesion and the glenoid is defined as an “off-track” lesion, and surgical treatment is indicated.4,5 Surgical options have been suggested to treat these off-track Hill-Sachs lesions, including open allograft humeral head reconstruction,6-9 although recently, remplissage showed good results at midterm follow-up.10-12

Despite good clinical results, a concern with remplissage is the potential for postoperative loss of external rotation.13,14 Recent findings suggested that overhead athletes are most affected even if differences in loss of rotation are not statistically significant.12 In addition to clinical studies, biomechanical research has evaluated causes of external loss of rotation. Elkinson et al15 found that anchor placement had a significant effect on postoperative range of motion and that overmedialization of anchors resulted in decreased external rotation and increased joint stiffness. Despite these findings, there was no suggestion...
as to appropriate suture placement, which may have a larger effect than anchor placement on postoperative range of motion.

Until recently, surgeons have assumed that the success of the remplissage procedure was attributable to infraspinatus tendon. Newer studies by Lädermann et al. and Garcia et al. refuted this theory and showed that suture passage for posterior tenodesis more often involves the muscle or musculotendinous junction. Further concerns from these studies are that fellowship-trained shoulder surgeons frequently overmedialize suture passage despite their knowledge of the literature and presumed technical expertise. These findings may help to explain the loss of external rotation reported in the literature, although most studies state that care was taken to avoid overmedializing suture passage, based on the recommendations of Elkinson et al. An additional concern in these 2 recent studies was posterior shoulder pain after remplissage. Both studies attributed this phenomenon to muscle perforation during suture passage.

After identifying inaccurate suture passage during arthroscopic remplissage, Garcia et al. suggested a method to decrease the prevalence of both complications. They described a “safe zone” technique for suture placement and determined retrospectively that percutaneous suture passage more than 1 cm lateral and less than 3 cm distal to the posterolateral acromion significantly increased the chance of infraspinatus tendon penetration. However, this was a retrospective recommendation, and this technique has not been validated.

Because few studies have described the placement of posterior tenodesis suture remplissage, further investigation is needed. The current study compared standard arthroscopic remplissage suture passage with the safe zone technique to determine whether the use of a described safe zone improved the accuracy and precision of suture passage through the infraspinatus tendon.

**Materials and Methods**

This study was conducted with 12 fresh frozen cadaveric shoulders. Mean donor age was 69.5 years, and the study included 7 female and 5 male specimens with average body mass index of 31.2 kg/m². No shoulder pathology was identified, and the same fellowship-trained sports medicine shoulder surgeon (J.S.D.) performed all procedures. The surgeon was blinded to the main study design. To maintain blinding of the lead surgeon for the second round of testing, the safe zone was calculated by the first author and the other authors. During the second round of testing, the lead surgeon was informed of the need to keep the percutaneous passes within the safe zone. All shoulders were mounted to produce a simulated beach chair position. The scapula was mounted to ensure that the glenoid was perpendicular to the floor and to simulate its anatomic position. Throughout the procedure and all testing, neutral humeral rotation was maintained by a surgical assistant. Standard arthroscopic remplissage was performed on a control group of 6 shoulders without the safe zone technique. In the remaining 6 cadaveric shoulders, arthroscopic remplissage was performed with the safe zone suture passage technique. A team member who was blinded to the surgical technique (C.A.K.) performed all dissections and measurements.

Arthroscopic remplissage was performed with a standard posterior viewing portal and an anterosuperior portal through the rotator interval, adjacent to the biceps tendon. After the presence of an intact rotator cuff was confirmed, the camera was placed anteriorly to evaluate the posterior humeral surface. A 70° arthroscope was used for posterior viewing. For anchor placement, the arm remained in a position of neutral rotation and neutral humeral adduction. Anchor placement was performed through an accessory posterolateral portal, similar to the technique of Boileau et al. For all specimens, 2 single-loaded anchors measuring 3 mm (SutureTak; Arthrex, Inc, Naples, Florida) were used. The superior anchor was placed 5 mm superior and 5 mm medial to the bare spot. The second anchor was placed 1 cm inferior to this site with the same medial landmarks (Figure 1). Both anchors were in the simulated off-track Hill-Sachs defect location. Because all procedures were performed arthroscopically, creation of a Hill-Sachs lesion was not feasible.

Sutures were then passed in a horizontal mattress configuration through the posterior rotator cuff by percutaneous passage of a spinal needle through the rotator cuff at the desired location of the tenodesis. All spinal needle trajectories were similar for percutaneous passes, and care was taken to keep the needle perpendicular to the humeral head, similar to previous studies. In addition, care was taken to avoid overmedializing the sutures in the control group.

For the safe zone group, the safe zone was drawn before the surgical procedure, as recommended by Garcia et al. and the spinal needle was again used percutaneously to pass the polydioxanone sutures. The needle was started within the safe zone for each pass, and trajectories were
similar for percutaneous passes. The safe zone was defined as greater than 1 cm lateral and no more than 3 cm distal to the posterolateral acromion (Figure 2). 

Corresponding pairs of sutures were marked for easier identification during dissection and measurement. Once all suture limbs had been passed arthroscopically, for both groups, the exit point of each suture limb with respect to the posterolateral acromion was recorded.

For both groups, all measurements were performed similarly. The arm was kept in neutral rotation with neutral humeral adduction, and measurements were performed with a manual caliper. An independent observer (C.A.K.) performed all measurements. The exit point of each suture limb with respect to the posterior lateral acromion was recorded. All limbs were held perpendicular to the humeral head to mimic similar entry and angle of the needles during the initial procedure. Distance from the posterolateral acromion was recorded, and dissection of the muscle or musculotendinous junction in the control group occurred in 75% (18 of 24) of cases, which was significantly greater than in the safe zone group (4.2%; 1 of 24) (P<.01). In addition, no suture passage in the safe zone group penetrated medial to the musculotendinous junction compared with 20.8% (5 of 24) in the control group (P<.01).

In the control group, average superior anchor suture passage was 31.2±5.6 mm and 28.2±8.7 mm distal to the posterolateral acromion compared with 16.3±3.8 mm and 20.5±3.7 mm, respectively, for the safe zone group (P<.01 and P=.09, respectively). Average lateral distance from the posterolateral acromion was 7.5±4.3 mm and 10.8±9.3 mm for the control group compared with 16.7±4.7 mm and 18.7±3.6 mm, respectively, for the safe zone group (P<.01 and P=.08, respectively). For the inferior anchor, average inferior distance from the posterolateral acromion was 26.3±8.5 mm and 25.2±5.6 mm compared with 25.2±3.3 mm and 28.5±3.8 mm, respectively, for the safe zone group (P=.03 and P=.07, respectively) (Table 1).

Average distance from the infraspinatus insertion for the superior anchor for the control group was 38.5±3.2 mm compared with 37.9±4.2 mm (P=.34) for the safe zone group. Average distance for the inferior anchor was 35.2±5.2 mm for the control group and 40.1±3.7 mm for the safe zone group (P=.38). Average vertical distance from the axillary nerve was 52.8±15.9 mm and 45.7±17 mm, respectively, for each anchor in the control group compared with 57.0±5.8 mm and 47.5±4.9 mm, respectively, for the safe zone group (P=.56 and P=.82, respectively).

The Shapiro–Wilk test determined that all data followed a normal distribution. Descriptive statistics were used to describe distances from the suture passes to the anatomic landmarks. Student’s t test was used to compare continuous variables, and the chi-square test or Fisher’s exact test was used to compare categorical variables. Levene’s test was used to compare the equality of variances to determine the precision of suture passes. Tests were conducted with 2-sided hypothesis testing. Statistical significance was set at P≤.05, and statistical tests were conducted with SPSS version 22.0 software (IBM, Armonk, New York).

RESULTS

For each group, 24 sutures were passed (4 sutures per specimen). For the control group, 25% (6 of 24) passed correctly through the infraspinatus tendon. This was significantly less than the number passed correctly in the safe zone group (83.3%; 20 of 24) (P<.01). Penetration of the muscle or musculotendinous junction in the control group occurred in 75% (18 of 24) of cases, which was significantly greater than in the safe zone group (4.2%; 1 of 24) (P<.01). In addition, no suture passage in the safe zone group penetrated medial to the musculotendinous junction compared with 20.8% (5 of 24) in the control group (P<.01).

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Comparative Analysis

The variance (SD) of the superior anchor suture passes improved from the control group from 3.6 mm to 3.8 mm (P=.54) and 8.7 mm to 3.7 mm (P=.03), respectively, for distal distance from the posterolateral acromion. For the lateral distance of the superior suture passage, variance changed from 4.3 mm to 4.7 mm (P=.67) and 9.3 mm to 3.6 mm (P=.13). Variance of the inferior anchor suture passes improved from 8.5 mm to 3.3 mm (P=.05) and 5.6 mm to 3.8 mm (P=.21) for the distal distance from the posterolateral acro-
mion. For the lateral distance, the variance of superior suture passage changed from 5.3 mm to 3.5 mm (P=.24) and from 5.4 mm to 5.1 mm (P=.89) (Table 2).

**Discussion**

The safe zone technique significantly improved the accuracy of infraspinatus tendon penetration during arthroscopic remplissage. Further, this technique reduced penetration of the muscle and musculotendinous junction during posterior tenodesis. The authors recommend use of the safe zone technique for percutaneous suture passage during remplissage, which consists of passing sutures more than 1 cm lateral and within 3 cm distal to the posterolateral acromion. This study showed that the safe zone technique increased the precision of suture passes between techniques, as evidenced by reduced variance between passes. Even though a growing number of studies recommend remplissage,10,12,24,25 limited data are available on the technical aspects of this technique.16,26-28 Despite descriptions of techniques to improve the remplissage procedure, even experienced arthroscopists frequently overmedialize sutures, producing a capsulomyodesis16 rather than an infraspinatus tenodesis.29 To the authors’ knowledge, this is the first study to validate a technique that improves the accuracy of suture passage, reducing overmedialization and potentially reducing the associated clinical complications of restricted range of motion and posterior shoulder pain.

Consistently, remplissage has been described as tenodesis of the infraspinatus tendon in the Hill-Sachs defect.11,24,25,29 More recent studies showed that successful infraspinatus tenodesis occurs in only approximately 25% of cases with standard techniques.16,17 This finding is consistent with the rates observed in the current control group, in which 25% of sutures passes were through the infraspinatus tendon. Because most surgeons use a similar technique, a new approach is needed to improve the accuracy of suture passage. In the current study, the safe zone technique improved accuracy. This finding is important because it shifts the remplissage from a capsulomyodesis16 to a true capsulotenodesis, as originally described by Purchase et al.29 In theory, improved tenodesis also may affect failure rates because pullout strength with mattress sutures through the muscle and musculotendinous junction is mechanically weaker than through the tendon.30,31 In addition, reducing the frequency of muscle and musculotendinous junction penetration may decrease failure rates, which have been reported to be as high as 10% to 15%, or decrease clinical dissatisfaction, as evidenced by high rates of posterior shoulder pain in up to 30% of patients.12,24,25,32 However, capturing muscle with suture still may lead to a successful outcome. Further biomechanical studies are needed to evaluate the benefit of the improved tendon penetration that occurs with the safe zone technique.

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<td><strong>Comparative Distances Between Groups</strong></td>
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<td>Distal distance from the posterolateral acromion</td>
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<td>Lateral distance from the posterolateral acromion</td>
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<td><strong>Comparative Analysis of Precision Between Groups</strong></td>
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²Levene’s scores were calculated for comparison of precision.
Concerns about loss of external rotation continue despite numerous studies that showed insignificant differences in range of motion. Even though statistical significance was not reached, average losses of up to 8° compared with the contralateral extremity have been reported. The clinical significance of this finding is difficult to discern, and many patients do not report loss of motion with daily activities. Recently, a more sensitive clinical marker has been decreased motion with overhead throwing. Garcia et al reported that up to 60% of patients reported lack of normal windup with throwing, although no patient in this group noted loss of range of motion with daily activities. These subtle differences in range of motion that affect only athletic activities may be an area where improved posterior suture passage techniques are beneficial.

Many studies cite Elkinson et al for preventing overmedialization; however, their study focused on anchor placement without a true solution to preventing overmedialization by suture passage. Even in recent studies by Lädermann et al and Garcia et al, care was taken to avoid overmedializing suture passage; however, in more than 75% of passes, the muscle and musculotendinous junction were imbricated. Alternative techniques are needed to prevent true overmedialization. The results of the current study show the ability of the safe zone technique to reduce the tendency to overmedialize. Quantitatively, the current findings showed significant improvement in lateralization of 6 to 10 mm with all passes with this technique.

With the continuing focus on avoiding medialization of the infraspinatus penetration, proximal and distal position of sutures and subsequent teres minor penetration also may have important implications for range of motion. In previous studies, teres minor capsulodasis occurred in up to 25% of cases, which is similar to the current findings. Biomechanical studies showed this to cause global loss of range of motion. Garcia et al discussed this concept of overdistalization and noted that placing sutures too distal may have a greater effect on range of motion deficits than overmedialization. In the current study, the safe zone technique showed a 10% improvement in teres minor penetration, which may have clinical implications. Further biomechanical evaluation is needed to determine the tethering effects of teres minor tenodesis and overdistalization.

Finally, arthroscopic remplissage is a technically challenging procedure that has an associated learning curve. Previous studies showed that even fellowship-trained shoulder surgeons often overmedialize and overdistalize suture passage. Use of the safe zone technique improved the accuracy and precision of suture passage and may help younger surgeons with less technical experience to perform posterior tenodesis. Overall, quantitatively and qualitatively, the safe zone technique improved the originally described remplissage procedure.

Limitations

As with most cadaveric studies, the current study had limitations. The primary limitation was the inability to evaluate this technique in vivo, which prevented the authors from correlating observed improvement in suture passage with improved clinical outcomes. Additionally, the sample size was limited, although it was comparable to similar reported studies. Overall body habitus, needle trajectory, and soft tissue swelling may affect the distance from the posterolateral acromion, although the current study attempted to control for this variation. For this reason, a zone rather than an exact point was evaluated to allow for variability in patients, and this zone may not be applicable for very small or morbidly obese patients. Finally, measurements were performed at the level of the soft tissue of the posterolateral acromion. The authors recommend marking the safe zone before arthroscopy to limit variation as a result of shoulder swelling.

In addition, the lack of biomechanical analysis precluded the authors from determining the effect of improved suture passage. However, this may not be clinically relevant. Small, statistically insignificant reductions in range of motion can adversely affect subjective athletic performance. Finally, the creation of off-track Hill-Sachs lesions may have strengthened this study. However, an arthrotomy would have been required to create these lesions, and that would have precluded an arthroscopic procedure.

Conclusion

This study compared a standard remplissage technique with a novel suture passage technique. The results showed significant improvement in the accuracy of suture passage into the infraspinatus tendon with the safe zone technique compared with the standard technique, which consists of passing all sutures greater than 1 cm lateral and within 3 cm distal to the posterolateral acromion. The safe zone technique provides a reproducible method that may help to prevent complications associated with arthroscopic remplissage.

References