JSES International 5 (2021) 66–71

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

Perceived vs. true glenoid anchor placement: a cadaveric comparison of the beach chair and lateral position

Benjamin Y. Jong, MD [a], Peter B. MacDonald, MD [a], William D. Regan, MD [b], Jeff R. Leiter, PhD [a], Eric C. Sayre, PhD [c], Treny M. Sasyniuk, MSc [d], Danny P. Goel, MD [e]*

[a] Pan Am Clinic and University of Manitoba, Winnipeg, Canada
[b] University of British Columbia and Department of Orthopaedics, Vancouver BC, Canada
[c] Eric Sayre Stats Consulting, Delta BC, Canada
[d] Sasyniuk Consulting, Vancouver BC, Canada
[e] University of British Columbia and Burnaby Orthopaedics, Burnaby BC, Canada

A R T I C L E I N F O

Keywords:
Bankart
instability
arthroscopy
beach chair
lateral decubitus
anchor

Level of evidence: Basic Science Study; Surgical Technique using Cadavers

Purpose: To explore whether patient position influences a surgeon's ability to accurately judge anchor position on the glenoid.
Materials and Methods: Two anchors were inserted into the glenoid of 8 shoulders. Arthroscopic videos were taken from 3 views (posterior beach chair [pBC], posterior lateral decubitus [pLD], and anterosuperolateral decubitus [asLD]). The shoulders were disarticulated to identify "true" anchor position. Seventeen shoulder surgeons reviewed the videos and indicated anchor positions using the "clock face" method. Accuracy was measured within tolerances, ranging from zero (exact), 0.5 (half-hour), 1.0, and 1.5 hours of "true" position. Intra- and inter-rater agreement was calculated. Post hoc analyses explored for bias dependent on surgical side.
Results: The overall accuracy was 34.0%. At tolerances of 0.5, 1.0, and 1.5 hours, accuracy increased to 82.4%, 95.4%, and 98.0%. With a 30° scope, identification of exact position was more accurate in pBC than pLD (odds ratio [OR] = 1.397; $P = .029$) but not asLD (OR = 1.341; $P = .197$). At a tolerance of 0.5 hour, the 30° scope was more accurate in pBC than both pLD (OR = 1.444; $P = .011$) and asLD (OR = 1.728; $P = .009$). In left shoulders, anchors were perceived as more inferior than true position in asLD and pLD. In right shoulders, anchors were perceived as more superior than true position from pBC and pLD. Inter- and intrarater agreement were highest in pBC with a 30° scope (30° scope weighted kappa = 0.783 and 70° scope weighted kappa = 0.853, respectively).
Conclusion: Judgment of anchor position on video is most accurate in a pBC view. Inter- and intrarater reliability were also highest from a pBC view.

Anterior shoulder instability (dislocation) is a common complaint presenting to the orthopedic surgeon. Treatment options include both nonoperative and operative strategies.[3,10] In those deemed high risk for redislocation, operative stabilization is considered.[10] Anterior instability is usually attributed to a soft tissue tear from the glenoid (Bankart lesion), causing the shoulder to dislocate.[9] The goal of surgical shoulder stabilization is to restore anatomy by securing the soft tissue back on the bone (Bankart repair) while avoiding complications.

Recurrence risk following arthroscopic anterior stabilization has been reported to be between 4% and 58%.[2] This variability has resulted in the need for further investigation as to the etiology of such recurrence; factors such as patient characteristics, glenohumeral bone loss, and technical characteristics such as a patient's position during surgery, may have a role in recurrent instability.[1,2] Arthroscopic shoulder stabilization surgery can be performed with the patient in 2 positions: beach chair (BC) or lateral decubitus (LD). Traditionally, surgeons believed both positions provided good surgical results; however, there is a growing debate surrounding this matter.[2] Proponents of the BC position suggest ease of transition to open procedures when necessary, ease of orientation due to the more anatomic shoulder position, and more favorable

Institutional review board approval was received from the University of British Columbia Clinical Research Ethics Board (CREB) (study no. H16-00406).
* Corresponding author: Danny P. Goel, MD, 106-3825 Sunset Street, Burnaby, BC, V5G 1T4, Canada.
E-mail address: danny.goel@ubc.ca (D.P. Goel).

https://doi.org/10.1016/j.jseint.2020.09.012
2666-6383/

ergonomics for the surgeon.[7] However, in a systematic review and meta-analysis of the literature, recurrence of shoulder instability following Bankart surgery from the BC position was found to be nearly double that of surgery performed from the LD position.[2] Proponents of the LD position advocate that there is improved visualization of the anterior glenoid compared to BC position.[2]

It is important for surgeons to understand whether patient positioning during surgery has an effect on surgical technique and ultimately, surgical outcomes. The purpose of this study was to explore whether patient position influences a surgeon's ability to accurately judge anchor position on the glenoid. We hypothesized that lateral decubitus position would allow for superior accuracy in the judgment of anchor position on the glenoid.

Materials and methods

Eight paired fresh-frozen, cadaveric shoulder specimens (4 left, 4 right) were used in this research. Each cadaver specimen was inspected by the University of Ottawa tissue bank for any surgical scarring prior to use in this study. Specimens with prior evidence of shoulder surgery were not accepted for the study. Each specimen was mounted on a vise grip to a laboratory table in an upright position. Portal placement was based on the usual bony landmarks (acromion and coracoid), and standard posterior and anterior arthroscopy portals were placed. Shoulder arthroscopy was performed. Although glenoid bone loss was not classified, we noted that no specimen had enough bone loss to preclude use of the clock face method. Two suture anchors (1.3-mm Yknot Flex; ConMed, Largo, FL, USA) were then randomly inserted into the anterior glenoid of each shoulder specimen. Following anchor placement, a series of 6 videos were taken on each specimen from 3 positions (posterior beach chair [pBC], posterior lateral decubitus [pLD], and anterosuperolateral decubitus [asLD]) with both 30° and 70° arthroscopes for a total of 48 videos (Figs. 1 and 2). For each specimen, the videos were taken in the following order: pBC, pLD, then asLD, first with the 30° and then the 70° arthroscope. Lateral decubitus views were simulated by changing scope orientation rather than altering specimen position. The videos ranged from 16 to 70 seconds in length, and all were ensured to show the entire glenoid and both anchors. All videos included captions for side (left or right) and orientation (superior/inferior, anterior) (Supplementary Video 1). All arthroscopic evaluations and anchors were inserted by a single upper extremity fellowship-trained surgeon (D.G.) to ensure consistency of camera position and orientation.

Shoulders were then disarticulated to provide an unobstructed view of the glenoid face. A digital picture was taken of each specimen's glenoid in sagittal view. In each image, the bare spot (when visible) was marked and a 10-cm metal ruler was placed next to the glenoid (in the same plane as the glenoid) (Fig. 3, *A*).

The digital images were uploaded into NIH ImageJ software (National Institutes of Health, Bethesda, MD, USA). A calibration factor was set for each image by measuring 10 mm on the ruler. Once the scale was set for the image, an ellipse was traced from the most superior to inferior aspect of the image. These 2 points represented the 12- and 6-o'clock positions of the glenoid, respectively. After tracing the ellipse on the image, the *x* and *y* coordinates for the centroid of the ellipse as well as the 12-, 3-, 6-, and 9-o'clock positions were established. A Cartesian coordinate system was applied to the ellipse, with the origin being placed at the centroid of the ellipse. Once the Cartesian coordinate system was established, the x and y coordinates of the 2 anchors, and the bare spot were established. In addition, the angle of each anchor and the "bare spot," with respect to the origin point of the Cartesian coordinate system was identified (Fig. 3, *B*).

The videos, along with standardized instructions and data collection forms, were sent to 17 upper extremity or sports fellowship–trained shoulder surgeons across the country for review. Surgeons were blinded to the arthroscopic view and degree of scope used as well as each other's findings. Reviewers viewed the videos in a randomized, nonsequential order to ensure they did not see the same glenoid from multiple different arthroscopic views at one time in order to prevent learning effect. Although seeing the same glenoid from multiple angles at one time could improve overall accuracy, it would prevent comparison of the different arthroscopic views, with views observed later in the sequence possibly having improved accuracy. Surgeons were asked to identify the position of the 2 anchors using the clock face method and to comment on their confidence of each assessment (weak vs. strong). Surgeons were instructed to identify anchor positions to the nearest half-hour (ie, 5:30, 6:00, 6:30). Number of instability cases per year were collected for each surgeon.

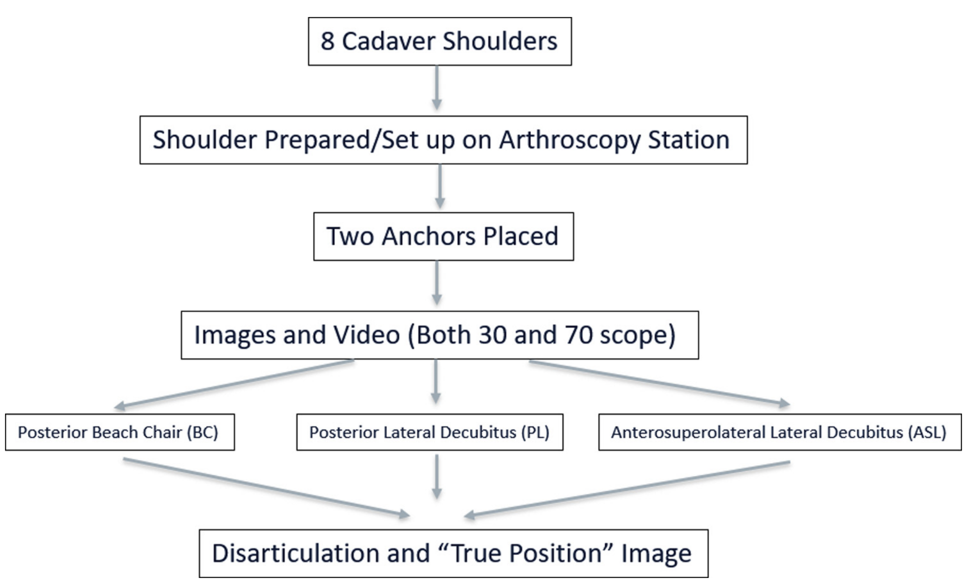

Figure 1 Flowchart summarizing the methodology of the present study.

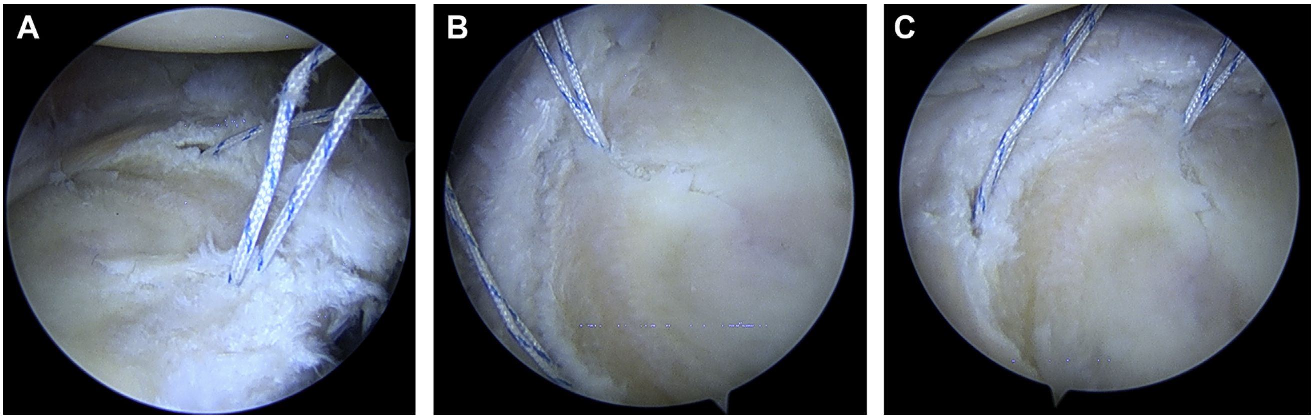

Figure 2 Example images of the different views used: (**A**) anterosuperolateral decubitus; (**B**) posterior beach chair; (**C**) posterior lateral decubitus. All images were taken with a 30° scope in specimen 1.

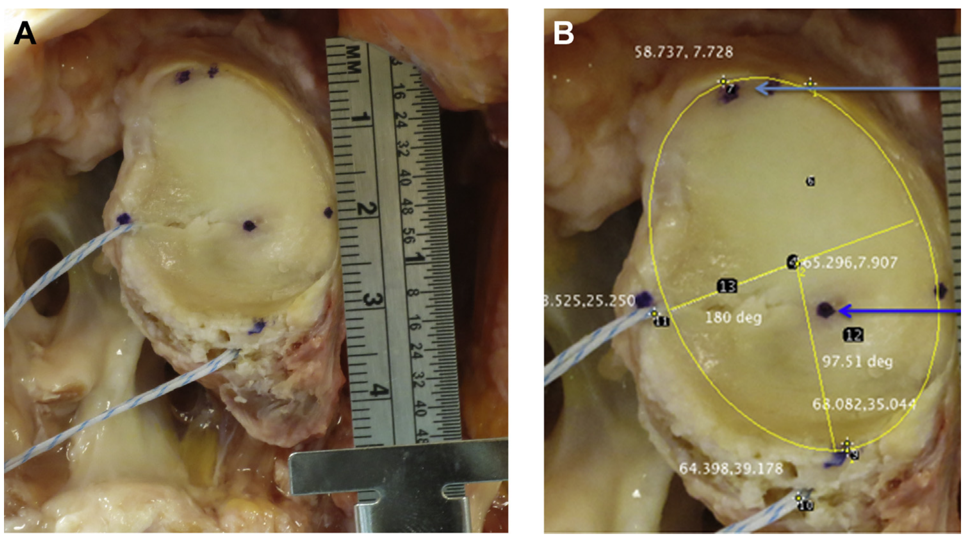

Figure 3 (**A**) Dissected glenoid with anchors placed. (**B**) Dissected glenoid with Image-J software elliptical clock overlay. →, 12 o'clock. →, bare spot.

Statistical considerations

The primary outcome of the study was surgeon accuracy judging anchor position on the glenoid clock face. Secondary outcomes included investigation of the effect of view (patient position), arthroscope angle, surgeon experience, and self-reported confidence of assessment on accuracy, sidedness, and inter- and intrarater reliability.

Accuracy was measured using the glenoid clock face as the unit of measurement. It was measured within a given tolerance, ranging from zero (exact position), 0.5 (within half-hour on the clock face), 1.0, and 1.5 hours of the true anchor position. Accuracy was calculated for each position (pBC, pLD, asLD) and for each arthroscope (30° and 70°). Odds ratios comparing the 3 positions were obtained using a binary generalized estimating equations model, Bonferroni-adjusted for multiple comparisons. Accuracy was modeled as a function of surgeon confidence and experience, view, scope, and the view-scope interaction. Intrarater and inter-rater agreement was calculated using weighted Kappas. Post hoc analysis was performed to determine whether there was a persistent bias in accuracy dependent on the side of the shoulder (right vs. left).

Results

Demographics

Seventeen shoulder surgeons consented to participate in the study. The mean years in practice was 12.3 years (range = 0-30 years), with 9 surgeons having more than 12 years of experience and 8 surgeons having less than 12 years of experience. The surgeons performed a median of 25 arthroscopic shoulder instability surgeries per year (range = 13-88 cases). Of the 16 surgeons currently in practice, 9 use BC, 6 use LD, and 1 uses both positions for instability surgery.

Accuracy

The overall accuracy of identifying exact anchor position on the glenoid was 34.0%. When identifying anchor position within tolerances of 0.5, 1.0, and 1.5 hours of the true anchor position, accuracy increased to 82.4%, 95.4%, and 98.0%, respectively.

The most accurate combination of view-and-scope tended to be the pBC view with a 30° scope (Table I). The interaction between view and scope was further explored using odds ratios

Table I
Accuracy (%) by view and arthroscope (30° vs. 70°)

Tolerance	aSL-30°	aSL-70°	pBC-30°	pBC-70°	pLD-30°	pLD-70°
Exact	31.6	31.2	40.4	34.7	32.5	33.4
Within 0.5 h	79.2	79.4	87.1	82.8	83.0	82.8
Within 1.0 h	94.5	95.5	96.3	95.3	94.3	96.5
Within 1.5 h	97.8	98.0	98.2	98.2	97.7	98.1

aSL, anterosuperolateral; *pBC*, posterior beach chair; *pLD*, posterior lateral decubitus.

(ORs; Tables II–IV). With a 30° scope, identification of exact anchor position was statistically more accurate in the pBC view than pLD (OR = 1.397; P = .029) but not when compared to asLD (OR = 1.341; P = .197). When tolerance was expanded to within a half-hour of exact anchor position, the 30° scope was more accurate in pBC than both pLD (OR = 1.444; P = .011) and asLD (OR = 1.728; P = .009). With a 70° scope, there were no statistically significant differences in accuracy between the 3 views at any level of tolerance (exact anchor position, 0.5, 1.0, 1.5 hours).

Inter-/intrarater agreement

Inter-rater agreement among surgeons was the highest in pBC with a 30° scope (weighted kappa = 0.783) and lowest in asLD with a 30° scope (weighted kappa = 0.681). Intrarater agreement was highest in pBC with a 70° scope (weighted kappa = 0.853) and lowest in asLD with a 30° scope (weighted kappa = 0.748).

Sidedness

In left shoulders, anchor position was perceived as more *inferior* than the true anchor position in both the asLD and pLD views (Fig. 4). In the asLD, the perceived anchor position was a mean 14.5 minutes more inferior on the clock face compared to the true position. In pLD, the perceived anchor position was a mean 7.6 minutes more inferior on the clock face compared to the true position.

In right shoulders, anchor position was perceived as more *superior* than the true anchor position from the pBC and pLD views (Fig. 5). In pBC, the perceived anchor position was 13.5 minutes more superior on the clock face compared with the true anchor position. In the right pLD, the anchor position was 11.4 minutes more superior on the clock face compared with the true position.

Confidence and experience

Surgeon confidence was positively correlated with accuracy in the exact position (OR = 1.647; P = .001), within 0.5 hour (OR = 1.610; P = .004) and within 1 hour (OR = 3.724; P = .000). Greater surgeon experience (ie, >12 years in practice) was negatively correlated with accuracy in the exact position (OR = 0.589; P = .008), within 0.5 hours (OR = 0.739; P = .084), and within 1 hour (OR = 0.525; P = .092).

Discussion

In the current study, the most accurate view was pBC with a 30° arthroscope. Odds ratio comparisons also identified pBC as superior to pLD for identification of exact anchor position and superior to both pLD and asLD with a 0.5-hour tolerance of exact anchor position. This supports the idea that the more anatomic position and orientation of the BC position lends itself to more accurate judgment of glenoid anchor position. Our finding that both inter- and intrarater reliability are higher in pBC compared with both LD views would also lend credence to the argument that the BC position is in fact more accurate for judgment of anchor position. This implies that the improved recurrence rates from LD position reported in the literature may have less to do with accurate judgment of anchor position and more to do with other factors inherent to LD, such as the use of traction to both improve access to the anterior glenoid, as well as accentuate labral tears that would otherwise be challenging to see.[2]

There was a dramatic difference in the overall accuracy between the exact and 0.5-hour tolerances. For judgment of anchor position to be considered correct at the exact tolerance, reviewers had to identify the anchor position to the nearest half-hour (ie, 6:30). At a tolerance of 0.5 hours, the possible "correct" answers for an anchor placed at 6:30 would include 6:00, 6:30, and 7:00. Having triple the chances of being correct likely explains this substantial increase in accuracy.

Surprisingly, more experienced surgeons were less likely to correctly identify anchor position at the exact, 0.5-, and 1-hour tolerances. One possible explanation for this may be related to the video review methodology of this study—a more experienced surgeon may be more accustomed to their own portal positions and the corresponding arthroscopic views obtained, thus reducing their accuracy when reviewing another surgeon's video.

Another unexpected finding of the current study was the effect of patient (specimen) side on judgment of anchor position. In the current study, anchor position was perceived as more inferior vs. true anchor position for left shoulders, whereas the opposite was true for right shoulders (anchor position perceived as more superior vs. true position) (Figs. 4 and 5). It should be noted, however, that the noted trend fell within the measurement interval. Surgeons were instructed to report anchor positions to the nearest half-hour, and the largest "sidedness bias" we reported was 14.5 minutes. Thus, the current study cannot definitively confirm the presence of sidedness bias.

Differences in anchor perception relating to the operative side have, to our knowledge, never before been reported in the literature. The ideal anchor position in Bankart surgery is typically described as anteroinferior, or sometimes "as inferior as possible."[4]

Table II
Comparison of pBC vs. asLD (30° scope)

pBC (exact)	1.341 (0.916-1.965)
pBC (within 0.5 h)	**1.728 (1.111-2.688)**
pBC (within 1.0 h)	1.113 (0.644-1.921)
pBC (within 1.5 h)	0.957 (0.306-2.986)

pBC, posterior beach chair; *asLD*, anterosuperolateral decubitus.
Values are odds ratio (95% confidence interval). Statistically significant findings are indicated in bold.

Table III
Comparison of pBC vs. pLD (30° scope)

pBC (exact)	**1.397 (1.005-1.904)**
pBC (within 0.5 h)	**1.444 (1.066-1.954)**
pBC (within 1.0 h)	1.482 (0.826-2.658)
pBC (within 1.5 h)	1.271 (0.585-2.763)

pBC, posterior beach chair; *pLD*, posterior lateral decubitus.
Values are odds ratio (95% confidence interval). Statistically significant findings are indicated in bold.

Table IV
Comparison of asLD vs. pLD (30° scope)

ASL (exact)	1.041 (0.769-1.409)
ASL (within 0.5 h)	0.836 (0.571-1.223)
ASL (within 1.0 h)	1.332 (0.720-2.465)
ASL (within 1.5 h)	1.329 (0.596-2.964)

asLD, anterosuperolateral decubitus; *pLD*, posterior lateral decubitus; *ASL*, anterosuperolateral.
Values are odds ratio (95% confidence interval).

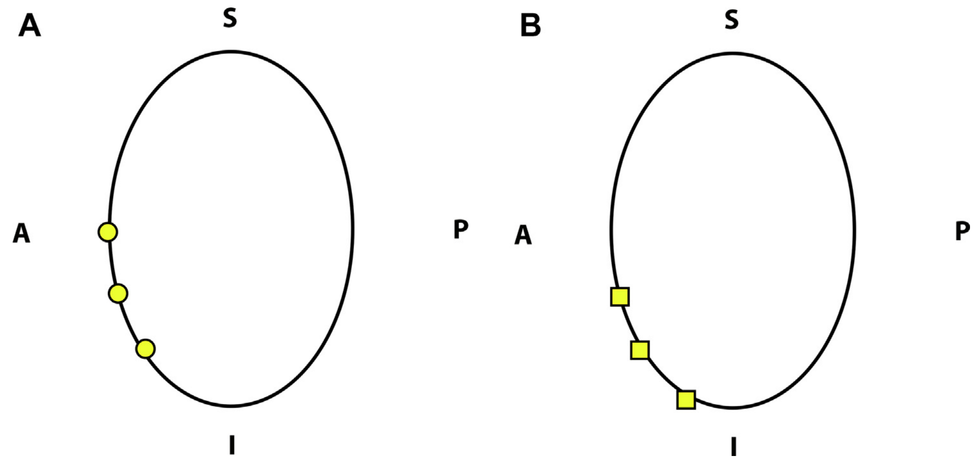

Figure 4 Schematic representation of left shoulder bias. The actual anchor position (**A**) was more superior than the perceived position (**B**).

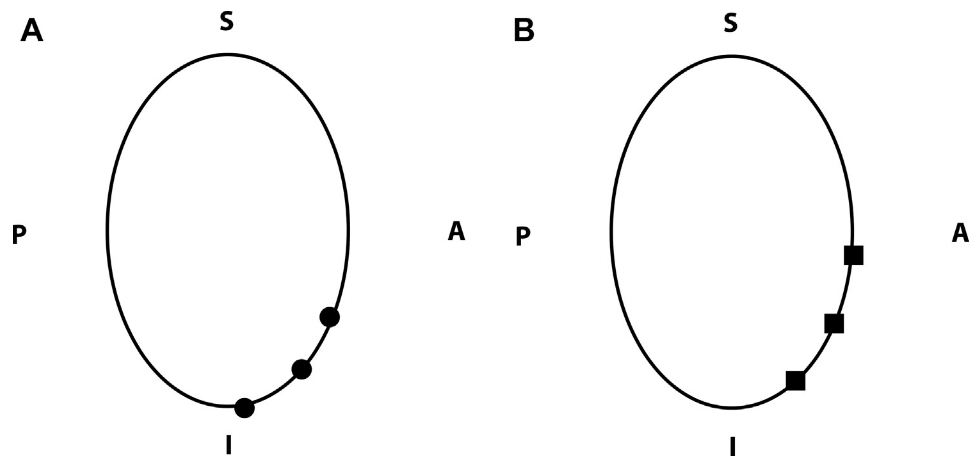

Figure 5 Schematic representation of right shoulder bias. The actual anchor position (**A**) was more inferior than the perceived position (**B**).

However, Ide and colleagues demonstrated in an anatomic study that the anterior band of the inferior glenohumeral ligament tended to originate between 2 and 5 o'clock, rather than 6 o'clock.[5] This is a subtle difference, but possibly significant when trying to anatomically repair the glenoid labrum. Stratification of the results of left- and right-sided surgeries may be an interesting avenue of research in Bankart surgery outcome studies.

The present study has several limitations. First, we had access to only 8 specimens in total. Although the negative correlation of experience with accuracy was significant at the exact tolerance, this only approached significance at 0.5 and 1 hour. More data points may have helped to clarify this relationship further. Visualization in a cadaveric shoulder may be different because of tissue tensions and color. This may have affected accuracy. Also, the elliptical clock overlaid onto the glenoid to determine true anchor position was created using the superiormost part of the glenoid ellipse "12 o'clock" and the inferiormost "6 o'clock," ignoring the bare spot. However, use of the bare spot as the clock face reference is known to be unreliable—in a cadaveric study by Kralinger et al, the bare spot was not found to be a consistent landmark for the center of a semicircle formed by the inferior rim of the glenoid.[6] The method of overlaying the elliptical clock used in the present study has also been used in other research.[8] Conceivably, the inclusion of specimens with enough bone loss or glenoid dysmorphism to allow for use of the clock face method would negatively affect reviewer accuracy. Although we did not classify bone loss arthroscopically in our specimens, we did not note enough loss to preclude use of the clock face method. Additionally, we were unable to assess relationships between surgeon handedness, surgical side, and accuracy because our surgeon participants only reviewed video; they did not perform the arthroscopies personally, and we did not capture their handedness or ocular dominance. An associated shortcoming of this study is that because surgeons only reviewed video, they did not benefit from the tactile feedback obtained when actively performing arthroscopy—thus, accuracy may have suffered as a result. Finally, this study only investigates the effect of viewing position/portal on the ability to correctly judge anchor position; determining whether or not this is important to clinical outcomes in instability surgery goes beyond the scope of the present study.

Conclusion

Our results suggest that a surgeon's judgment of anchor position on video is most accurate when viewed from a pBC view (ie beach chair position). Inter- and intrarater reliability were also highest from a pBC view. We unexpectedly found that surgeon experience correlated negatively with accuracy, though further study is necessary to determine the clinical significance and cause of this. Finally, our study provides novel information regarding a possible inherent bias in right- vs. left-sided arthroscopic Bankart surgery, wherein anchor position was interpreted differently depending on which side of the patient was observed.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jseint.2020.09.012.

Disclaimer

Benjamin Y. Jong has received funding from Arthrex to attend an educational course.

Peter B. MacDonald is a consultant for ConMed (Utica, NY, USA) and has received fellowship funding from Arthrex (Naples, FL, USA) and Ossur (Reykjavik, Iceland).

The other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References

1. Balg F, Boileau P. The instability severity index score: a simple pre-operative score to select patients for arthroscopic or open shoulder stabilisation. J Bone Joint Surg Br 2007;89:1470–7. https://doi.org/10.1302/0301-620X.89B11.18962.
2. Frank RM, Saccomanno MF, McDonald LS, Moric M, Romeo AA, Provencher MT. Outcomes of arthroscopic anterior shoulder instability in the beach chair versus lateral decubitus position: a systematic review and meta-regression analysis. Arthroscopy 2014;30:1349–65. https://doi.org/10.1016/j.arthro.2014.05.008.
3. Grumet RC, Bach BR, Provencher MT. Arthroscopic stabilization for first-time versus recurrent shoulder instability. Arthroscopy 2010;26:239–48. https://doi.org/10.1016/j.arthro.2009.06.006.
4. Hendawi T, Milchteim C, Ostrander R. Bankart repair using modern arthroscopic technique. Arthrosc Tech 2017;6:e863–70. https://doi.org/10.1016/j.eats.2017.02.019.
5. Ide J, Maeda S, Takagi K. Normal variations of the glenohumeral ligament complex: an anatomic study for arthroscopic Bankart repair. Arthroscopy 2004;20:164–8. https://doi.org/10.1016/j.arthro.2003.11.005.
6. Kralinger F, Aigner F, Longato S, Rieger M, Wambacher M. Is the bare spot a consistent landmark for shoulder arthroscopy? A study of 20 embalmed glenoids with 3-dimensional computed tomographic reconstruction. Arthroscopy 2006;22:428–32. https://doi.org/10.1016/j.arthro.2005.12.006.
7. Lohre R, Regan W, Goel DP. Surgeon ergonomics during arthroscopic shoulder surgery. J Orthop Exp Innov 2020 (Accepted for publication).
8. Pogorzelski J, Muckenhirn KJ, Mitchell JJ, et al. Biomechanical comparison of 3 glenoid-side fixation techniques for superior capsular reconstruction. Am J Sports Med 2018;46:801–8. https://doi.org/10.1177/0363546517745626.
9. Streubel PN, Krych AJ, Simone JP, et al. Anterior glenohumeral instability. J Am Acad Orthop Surg 2014;22:283–94. https://doi.org/10.5435/JAAOS-22-05-283.
10. Voos JE, Livermore RW, Feeley BT, et al. Prospective evaluation of arthroscopic Bankart repairs for anterior instability. Am J Sports Med 2010;38:302–7. https://doi.org/10.1177/0363546509348049.