Technical Note

Bubble Sign to Confirm the Integrity of the Shoulder Rotator Cuff

Maciej J. K. Simon, M.D., and William D. Regan, M.D., F.R.C.S.C.

Abstract: The presence of an intra-articular air bubble adjacent to the rotator cuff at the time of diagnostic shoulder arthroscopy will confirm an intact rotator cuff and is helpful in ambiguous cases. After the introduction of the arthroscope, air is pulled owing to negative air pressure in the joint cavity. Fluid inflow is then started after the inflow has been properly flushed of all air. This creates an intra-articular air bubble, which can be found at the top of the capsular-supraspinatus attachment site in cases with an intact rotator cuff. Secondary subacromial positioning of the arthroscope is used to confirm the intact rotator cuff from the bursal side.

Arthroscopy is the gold standard for the diagnosis and management of rotator cuff pathology.[1] First, during arthroscopic surgery, one must identify and confirm the tear location, type, and size, previously seen on ultrasound or magnetic resonance imaging (MRI).[2,3] There are often discrepancies noted between the MRI scans, clinical signs and symptoms of the patient, and status of the rotator cuff on direct visualization, which is the gold standard.[4] In many ambiguous cases, because of the positive findings on the MRI scans (Figs 1 A and B, 2A, and 3), arthroscopy is performed, but occasionally, full-thickness or significant partial-thickness tears are not found.[5] However, there is always an air bubble present intra-articularly at the highest level in the joint capsule (Figs 1C and 2B), which is usually adjacent to the supraspinatus footprint area depending on patient placement in the lateral decubitus position. This bubble helps to confirm that no+ tear is present.

Technique

After the decision is made to proceed with arthroscopic surgery, informed consent is obtained. The patient is placed in the lateral decubitus position (Fig 4) with the arm placed in a holding device in the abducted position with slight traction (e.g., Spider 2 Limb Positioner [Smith & Nephew, Andover, MA]). Before the introduction of an arthroscope with a blunt trocar into the shoulder joint, the fluid (saline solution) inflow is flushed properly to eliminate any air bubbles without being attached to the arthroscope (Fig 5, Video 1). The posterior portal is established via a skin puncture (Fig 6, Video 1). The arthroscope is then introduced into the shoulder joint, and the trocar is removed. At this moment, owing to negative intra-articular pressure, a minimal amount of air is sucked into the arthroscope (and joint) depending on the individual negative air pressure levels (Fig 7, Video 1).[6] The camera is then introduced into the joint via the arthroscope, and correct intra-articular positioning is confirmed. Thereafter, fluid inflow is established (Video 1). With the camera's introduction into the arthroscope and fluid inflow, the remainder of the air in the arthroscope is pushed into the joint. During the intra-articular diagnostic arthroscopy, an air bubble can be seen at the capsular-supraspinatus attachment to the humerus with an intact rotator cuff because it cannot escape an enclosed environment (Figs 1C, 2B, and 8-11; Video 1). Further subacromial placement of the arthroscope is needed to exclude any bursal-sided or delaminated rotator cuff tears (Fig 12, Video 1), often with the help of a hook

From the Department of Orthopaedics, University Medical Center Hamburg-Eppendorf, Hamburg, Germany (M.J.K.S.); and Department of Orthopaedics, University of British Columbia, Chan Gunn Pavilion, Allan McGavin Sports Medicine Clinic, Vancouver, British Columbia, Canada (M.J.K.S., W.D.R.).

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Address correspondence to William D. Regan, M.D., F.R.C.S.C., Department of Orthopaedics, University of British Columbia, Chan Gunn Pavilion, Allan McGavin Sports Medicine Clinic, 2553 Wesbrook Mall, Vancouver, BC, Canada V6T1Z3. E-mail: wregan@mail.ubc.ca

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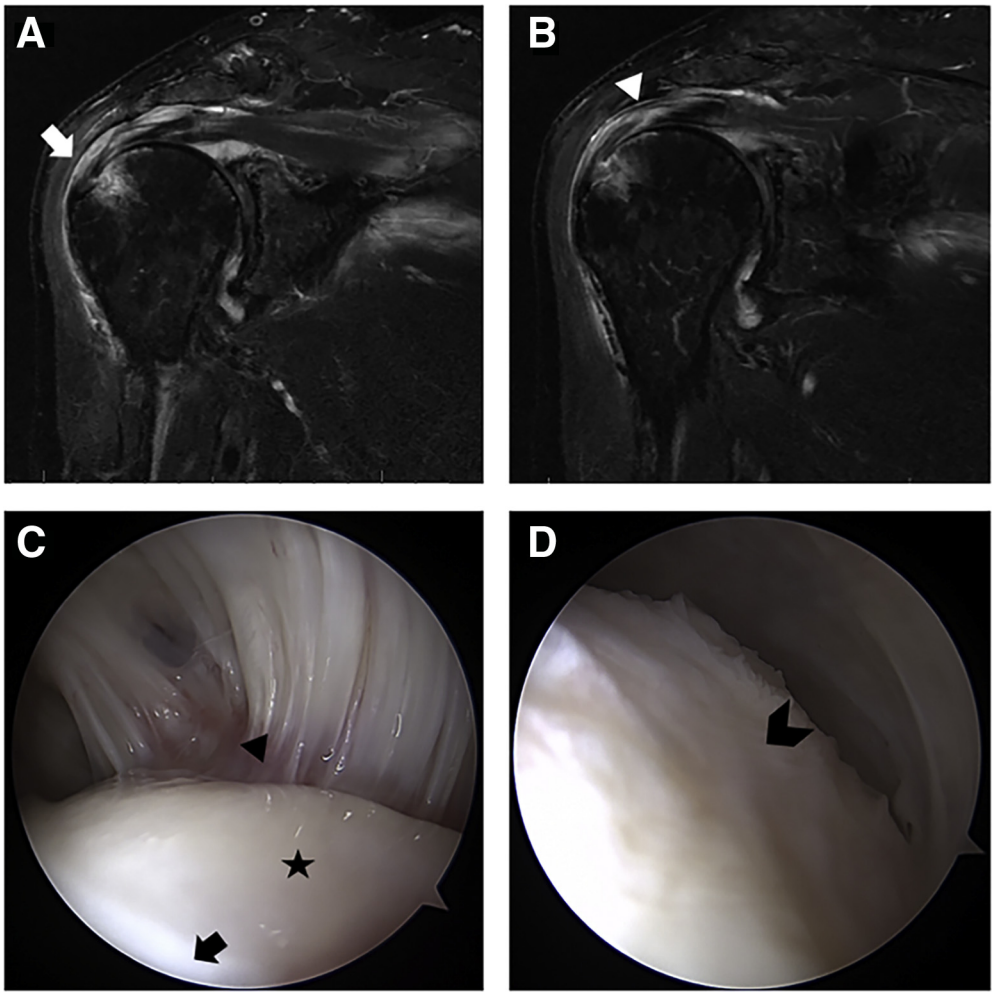

Fig 1. (A, B) T2-weighted coronal magnetic resonance imaging scans of a right shoulder showing increased signal intensity at the supraspinatus insertion (white arrow) and intratendinous irregularities (possible intrasubstance tear; white triangle). (C) Intra-articular arthroscopic visualization of the corresponding right humeral head (black star) and supraspinatus footprint area (black triangle) through the posterolateral portal in the lateral decubitus position from inside an air bubble (the edge of which is seen at the lower left corner; black arrow) shows the supraspinatus attachment. (D) Subacromial positioning of the arthroscope through the posterolateral portal in the lateral decubitus position confirms an intact rotator cuff (black chevron).

instrument via an additional portal because it can be masked without probing (Figs 1D, 2 C and D, and 13; Video 1). At this time, the previously found intra-articular air bubble confirms an intact rotator cuff.

If no air bubble is seen intra-articularly, the likelihood of a rotator cuff tear, even a minor delaminated[7] or intrasubstance tear, is very high. Air bubbles can escape from the smallest irregularities in rotator cuff tears and can dissipate into smaller bubbles in the subacromial space (Fig 14).[8,9] This is often the case with intrasubstance or very small full-thickness rotator cuff tears; therefore, no proper air bubble is noted in these cases (Fig 15). Thus, we perform and suggest an extended search and probing for a tear.

On another note, if the inflow has not been flushed properly of air bubbles, the bubble sign can yield a false-positive finding. Sometimes, in massive rotator cuff tears, a bubble sign can be present in the subacromial space because the air bubble can simply escape without being disrupted. Pearls and pitfalls of the described technique are presented in Table 1, and advantages and disadvantages are listed in Table 2.

Discussion

Many rotator cuff tears seen on MRI scans are not confirmed by arthroscopic surgery.[5] The use of the bubble sign can help to exclude a rotator cuff tear during an arthroscopic live view. We have used this arthroscopic bubble sign without any complications. Nonetheless, there are limitations to the bubble sign. The inexperienced arthroscopist may not appreciate that the bubble sign is meant to be an adjunct to and should not substitute for a full and careful review of the rotator cuff from the intra-articular side and the subacromial space. The bubble sign will not rule out a bursal-sided tear; it can be present in this type of tear.

However, this technique works in both the lateral decubitus and beach-chair position; only the intra-articular air bubble position varies slightly. Furthermore, this technique aspect is very simple to

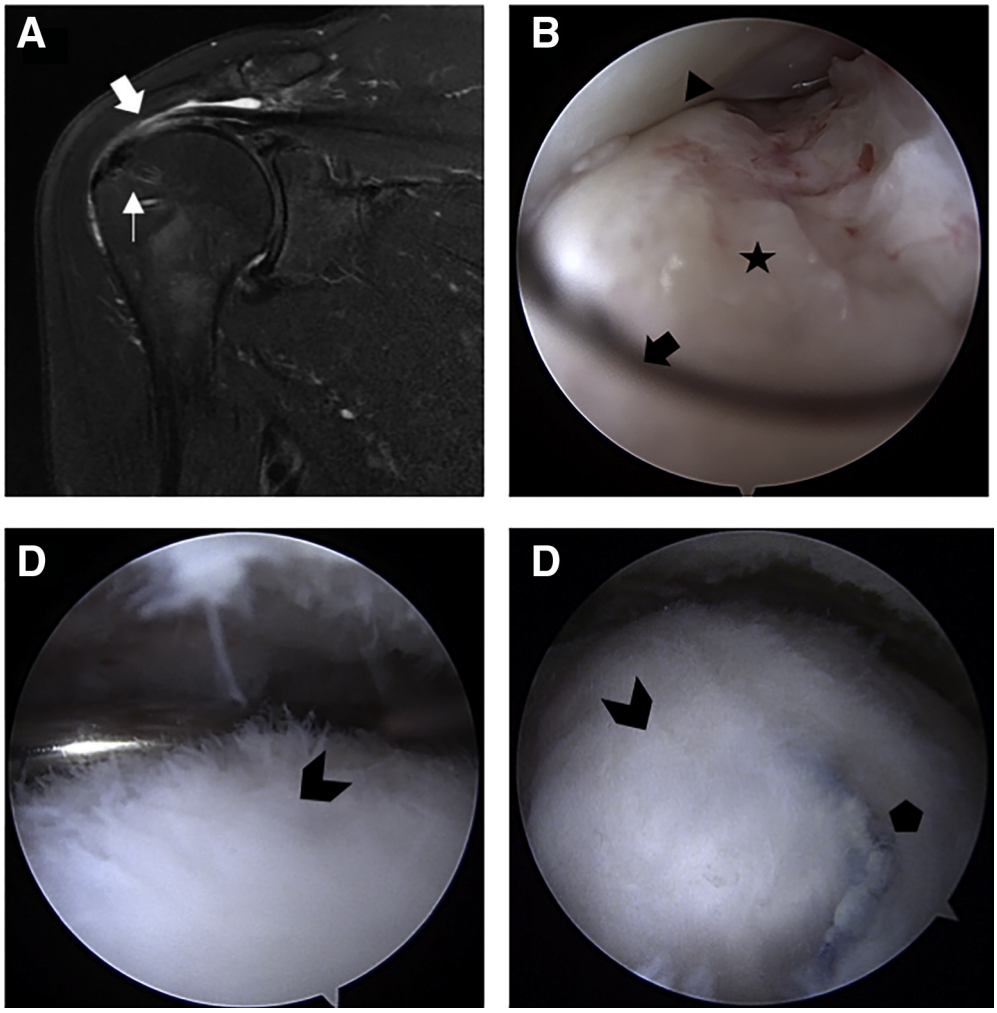

Fig 2. (A) Magnetic resonance image (T2 weighted, coronal) of a left shoulder showing a previously placed anchor (thin white arrow) in the humerus from prior rotator cuff surgery and a possible disruption of the supraspinatus tendon (thick white arrow). (B) An intra-articular arthroscopic view of the left shoulder through a posterolateral portal at the footprint area with the patient in the lateral decubitus position shows the positive bubble sign (black arrow) and complete attachment (humeral head; black star) and continuity of the supraspinatus tendon (black triangle). Probing the rotator cuff (black chevron) from the subacromial space via the posterolateral portal confirms intactness (C) and nonabsorbable suture material (black pentagon) despite some tissue fraying (D).

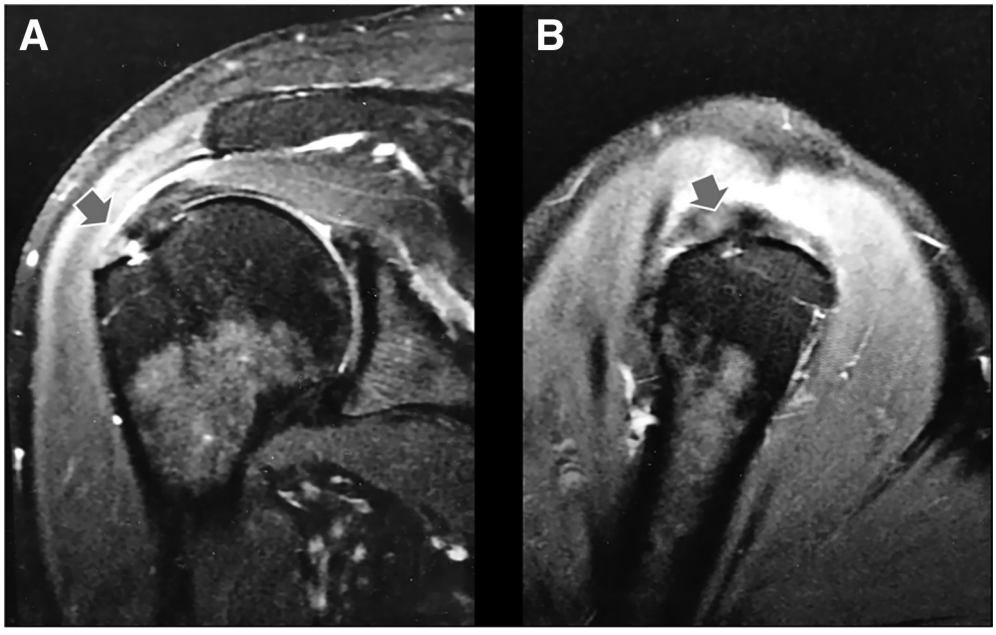

Fig 3. Magnetic resonance images of the right shoulder (T2 weighted) show a signal intensity increase and potential lesion of the supraspinatus tendon (gray arrows) more in the coronal plane (A) than in the sagittal plane (B).

Fig 4. The patient is positioned in the left lateral decubitus position. The posterolateral acromion corner (black arrow) of the right shoulder is marked. The incision for the posterolateral portal (white star) is drawn approximately 1 cm medial and approximately 2 cm inferior to the posterolateral corner of the acromion.

Fig 5. After preparation and draping, the inflow is flushed properly to eliminate entrapped air bubbles in the tubing system.

Fig 6. Skin puncture of the right shoulder for establishment of posterolateral portal.

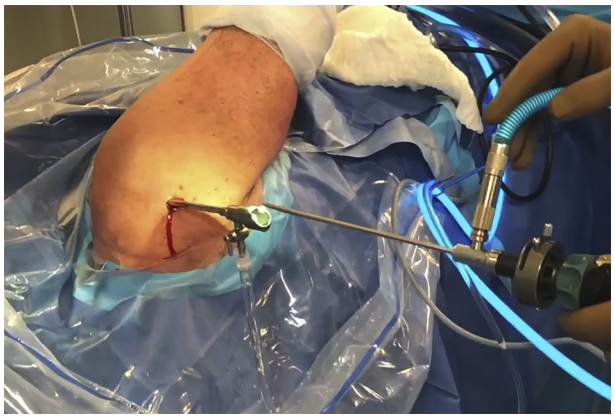

Fig 7. After placement of the arthroscope in the posterolateral portal and removal of the blunt trocar, air is sucked into the arthroscope and/or joint depending on the negative intra-articular pressure. Further air is pushed into the right shoulder joint with the introduction of the camera into the arthroscope.

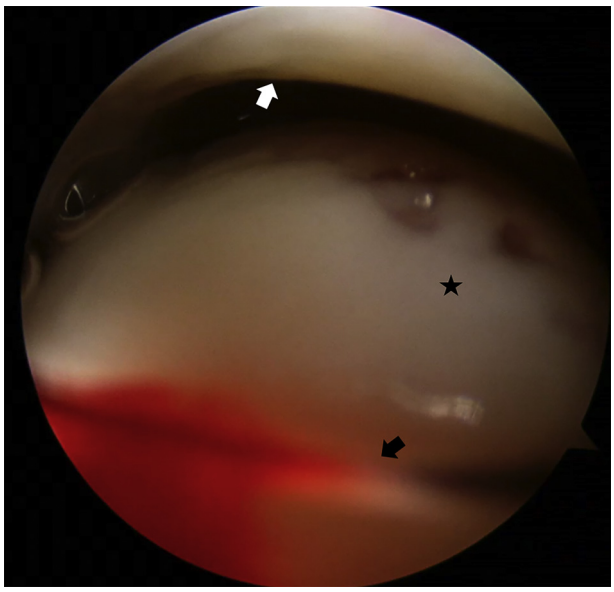

Fig 8. Fluid inflow is established to clear debris. Immediately, an air bubble (black arrow) can be seen intra-articularly via the posterolateral viewing portal on top of the right humeral head (black star; with patient in the left lateral decubitus position). This camera position can almost be mistaken for a dry arthroscopy. The rotator cuff (white arrow) is seen at the top.

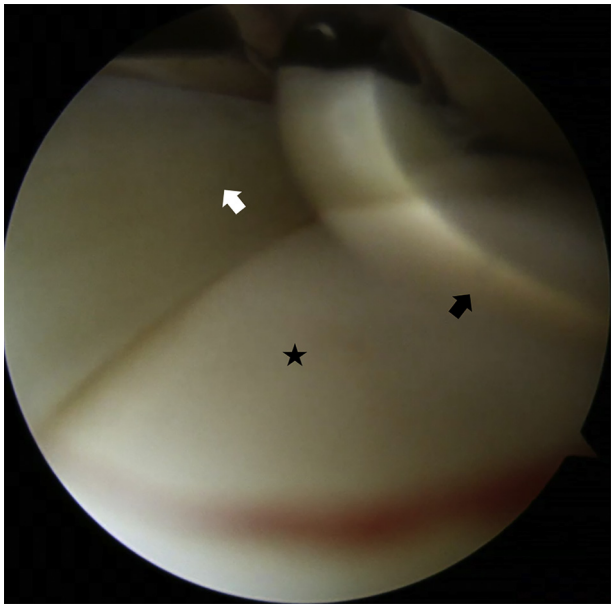

Fig 9. From the posterolateral viewing portal, the long head of the biceps tendon (white arrow) of the right shoulder can be seen crossing the humeral head (black star) in front of the air bubble (black arrow).

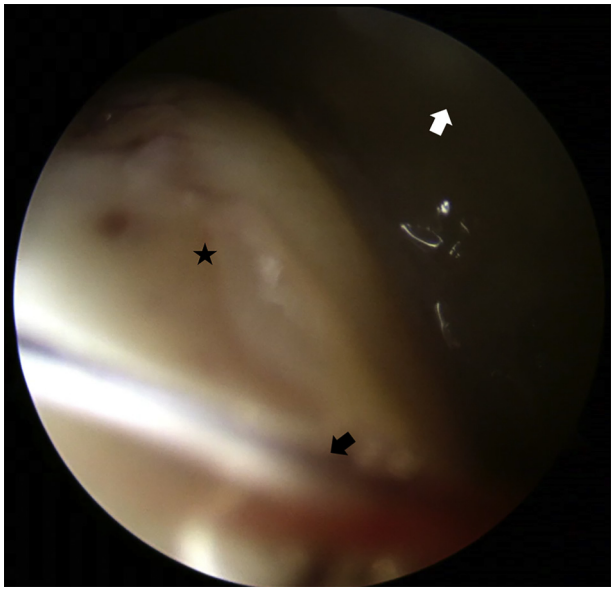

Fig 11. When the camera is pulled back farther, positioned in the posterolateral viewing portal of the right shoulder with patient in the lateral decubitus position, the posterior aspect of the humeral head (black star) is visualized and shows an intact infraspinatus attachment (white arrow) from the intra-articular side. In the inferior part of the image, the edge of the air bubble (black arrow) is seen.

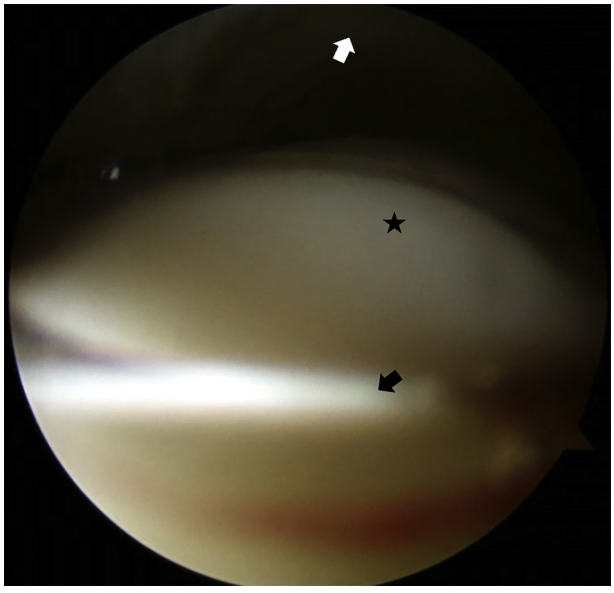

Fig 10. When the camera in the right shoulder joint is moved toward the back, the edge of the air bubble (black arrow) can be seen from the posterolateral portal over the humeral head (black star). At the superior margin of the image, the intact rotator cuff (supraspinatus; white arrow) can be seen and is entrapping the air bubble intra-articularly.

Fig 12. The arthroscope and camera are positioned via a posterolateral viewing portal in the subacromial space of the right shoulder. After clearance of the bursa with a shaver (white arrow) from the midlateral portal, the rotator cuff is inspected (black star).

Fig 13. Full inspection of the rotator cuff (black star) with the camera positioned through the posterolateral portal in the subacromial space of the right shoulder shows a completely intact rotator cuff and confirms the previously found intra-articular bubble sign.

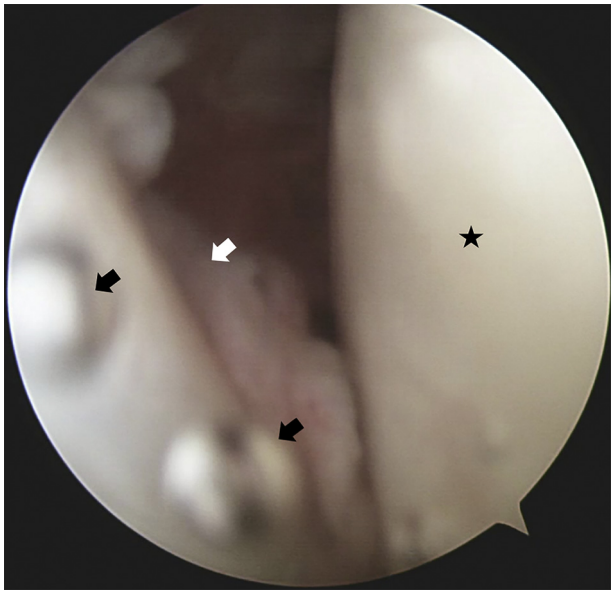

Fig 14. As the camera is introduced into the right shoulder joint with the patient in the lateral decubitus position, viewing the humeral head (black star) and the anterior glenoid rim with a torn labrum (white arrow) from the posterior portal, the air bubbles (black arrows) that are introduced disperse immediately through the torn rotator cuff into the subacromial space.

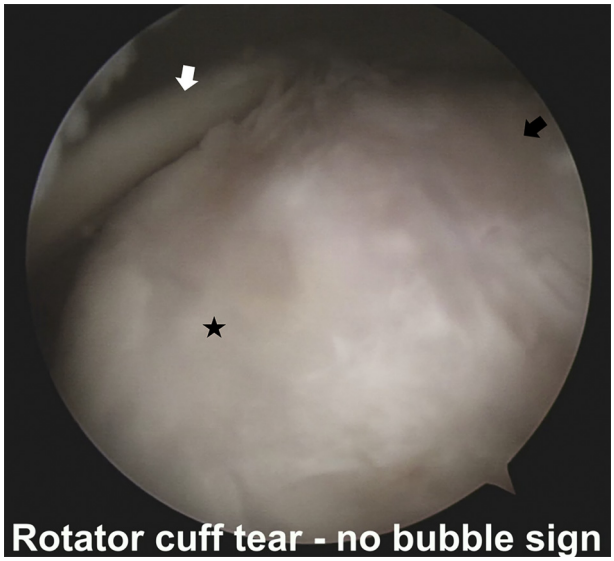

Fig 15. Diagnostic arthroscopy via the posterior portal and patient in the lateral decubitus shows the long head of the biceps tendon (white arrow) passing through the right shoulder joint. The humeral head (black star) is completely denuded (black arrow). This finding confirms a full-thickness rotator cuff tear; therefore, no bubble sign is visible.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
The bubble sign helps to confirm an intact rotator cuff.	If the inflow is not flushed properly, air bubbles can cause a false-positive finding regarding cuff integrity.
This simple observation can be performed during diagnostic arthroscopy.	The position of the patient (lateral decubitus vs beach chair) changes the air bubble position slightly.
Placing the camera against the outside of the air bubble allows for dry arthroscopy and an enhanced view of partial-thickness tears (rim-rent tears).	Surgeons should not try to substitute the bubble sign for a thorough arthroscopic review including the subacromial space.

Table 2. Advantages and Disadvantages

Advantages
No special instrumentation needed
Can be integrated into every arthroscopy
No additional skills required
Educational and visual aid for explaining rotator cuff integrity to patients
Disadvantages
Over-reliance on bubble sign for cuff integrity

incorporate into arthroscopic surgery. We believe that this intra-articular bubble sign can help to reduce prolonged search and/or surgery times and confirm an intact rotator cuff in questionable cases.

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