Technical Note

Arthroscopic Acromioclavicular Joint Reconstruction Using Knotless Coracoclavicular Fixation and Soft-Tissue Anatomic Coracoclavicular Ligament Reconstruction

Travis J. Menge, M.D., Dimitri S. Tahal, M.Sc., J. Christoph Katthagen, M.D., and Peter J. Millett, M.D., M.Sc.

Abstract: Acromioclavicular joint injuries are one of the most common shoulder injuries, and there are a variety of treatment options. Recently, there have been newer arthroscopic techniques that have addressed coracoid and clavicle fracture risk by using a knotted suture-button fixation through a single, small bone tunnel with additional looped soft-tissue graft stabilization. Although clinical outcomes have been good to excellent, there have still been instances of knot and hardware irritation. The described technique builds on the latest advances and achieves an anatomic coracoclavicular (CC) reconstruction through a single knotless CC fixation device with additional soft-tissue allograft reconstruction of the CC ligaments. This technique minimizes the risks of coracoid and clavicle fractures and knot and hardware irritation while maintaining excellent stability.

Acromioclavicular (AC) joint injuries are one of the most common shoulder injuries, with an estimated incidence of 1.8/1,000 per year, and approximately 50% are sustained by athletes participating in contact sports.[1,2] Although the treatment of Rockwood grade III AC joint injuries is controversial, a recently described subclassification may have helped solve the treatment algorithm with evidence supporting nonoperative treatment of Rockwood grades I, II, and IIIA (horizontally stable) whereas Rockwood grades IIIB (horizontally unstable), IV, V, and VI should be treated with surgical reconstruction.[3]

Historically, open procedures have been the dominant surgical treatment strategy, although more recently, arthroscopically assisted techniques have become more popular because of the minimally invasive operation, the enhanced visualization, and the ability to diagnose and treat concomitant glenohumeral pathologies, which are common in higher-grade injuries. Complications of AC joint reconstruction techniques include coracoid or clavicle fractures, loss of reduction, and residual shoulder pain sometimes resulting from knot or hardware irritation at the superior clavicle fixation site, where there is minimal soft-tissue coverage.[4-6]

For AC joint reconstruction techniques using suture-button systems and/or soft-tissue grafts, the risk of coracoid and clavicle fractures is associated with the number and size of drill holes and bone tunnels.[7,8] Single-point fixation devices were sometimes inadequate and loss of reduction occurred, so techniques using 2 self-reinforcing suture-button systems to recreate each of the coracoclavicular (CC) ligaments were developed. These required multiple drill holes and bone tunnels, which sometimes resulted in clavicle or coracoid fractures. These double tightrope constructs evolved into single suture-button systems with thicker tape-like suture and larger buttons to better dissipate the forces.[9] Additional soft-tissue grafts to reconstruct the CC ligaments are advocated by most investigators for chronic cases,[3,10] whereas others advocate soft-tissue graft reconstruction of the CC

From Steadman Philippon Research Institute (T.J.M., D.S.T., J.C.K., P.J.M.) and The Steadman Clinic (T.J.M., P.J.M.), Vail, Colorado, U.S.A.

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Address correspondence to Peter J. Millett, M.D., M.Sc., The Steadman Clinic, 181 W Meadow Dr, Ste 400, Vail, CO 81657, U.S.A. E-mail: drmillett@thesteadmanclinic.com

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Table 1. Indications and Contraindications

Indications
Acute and chronic Rockwood type IV-VI injuries
Horizontally unstable Rockwood type IIIB injuries
Symptomatic type IIIA injuries that have failed conservative management
Contraindications
Active infection around surgical site
Medical comorbidities that preclude patient as surgical candidate

ligaments in all cases of surgical AC joint reconstruction, with the goal of achieving improved primary stability.[1,6]

Techniques that obviate drill holes in which the soft-tissue graft is looped around the coracoid and clavicle were developed to decrease the risk of clavicle or coracoid fracture.[9] Despite the advantage of single bone tunnels with a lower fracture risk, these newer techniques had the disadvantage of having a thicker knot stack on top of the clavicle.[11,12] In a systematic review assessing the rates of complications of AC joint procedures, Woodmass et al.[11] identified hardware irritation as the most common source of postoperative pain, with 4 studies using a suture-button fixation technique reporting the rate of this complication as 25% or greater.

An arthroscopically assisted anatomic CC ligament reconstruction technique that combines the potential advantages of a low-profile CC fixation device without knots and an anatomic reconstruction of the CC ligaments with a graft is presented in this report. The technique can be combined with an additional looped tendon graft stabilization for the treatment of both acute and chronic AC joint dislocations requiring surgical reconstruction.

Surgical Technique

Operative Indications

The surgical indications for AC reconstruction include acute and chronic Rockwood type IV through VI injuries, horizontally unstable Rockwood IIIB injuries, and symptomatic type IIIA injuries that have failed conservative management.[3,13] The indications and contraindications for the procedure are outlined in Table 1.

Patient Positioning and Anesthesia

The patient is placed in the beach-chair position with the injured upper extremity in an arm holder (Smith & Nephew, Andover, MA), with the nonsurgical extremity placed on a padded arm board (Video 1). A large C-arm is positioned to allow intraoperative fluoroscopy and to confirm anatomic reduction of the AC joint. The surgical shoulder is prepared and draped in the usual sterile fashion.

Diagnostic Arthroscopy and Coracoid Preparation

First, a standard diagnostic shoulder arthroscopy is performed with a 30° arthroscope through a posterior portal. An anterior portal is created lateral to the coracoid using spinal needle localization followed by insertion of a 5-mm cannula (Arthrex, Naples, FL), and any concomitant intra-articular pathology is addressed (Video 1). Next, a mechanical shaver and radiofrequency ablator are placed through the anterior cannula to debride the subcoracoid space and expose the inferior aspect of the coracoid. At this point, a 70° arthroscope can be used to help improve visualization while the subcoracoid region is being debrided.

Knotless CC Fixation

Once the coracoid is adequately exposed, a 2- to 3-cm incision is made over the distal end of the clavicle perpendicular to its long axis, approximately 3 cm medial to the AC joint (Fig 1). The skin and subcutaneous tissues are sharply dissected to expose the superior aspect of the lateral clavicle. Next, an anteroinferolateral (AIL) portal is created inferior and lateral to the previously placed anterior portal. An 8.25-mm cannula (Arthrex) is inserted through the AIL portal, and an AC aiming guide (Arthrex) is placed through the cannula. The drilling sleeve on the guide is placed on the superior aspect of the clavicle, centered anterior to posterior, whereas the aiming arm is positioned on the undersurface of the coracoid, centered medial to lateral (Fig 2).

A cannulated drill (Arthrex) is then drilled through the clavicle and coracoid under direct arthroscopic visualization. Great care must be taken to ensure that the cannulated drill enters in the superocentral portion of the clavicle and that it exits at the posteroinferior aspect of the coracoid. A unicortical reamer (Arthrex) is placed over the pin and is used to ream the superior cortex of the clavicle (Fig 3). This step is performed to create a small socket to allow the clavicle insert device

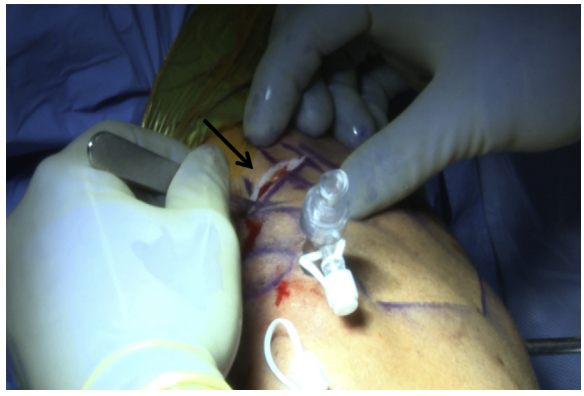

Fig 1. A 2- to 3-cm incision (arrow) is made over the distal end of the clavicle perpendicular to its long axis, approximately 2 cm medial to the acromioclavicular joint, in a left shoulder with the patient placed in the beach-chair position.

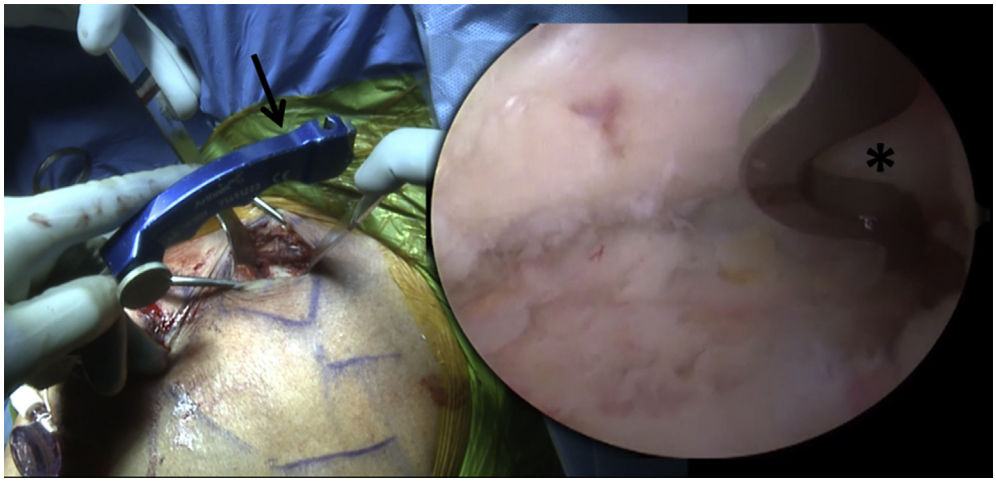

Fig 2. An acromioclavicular aiming guide (arrow) is placed through the anteroinferolateral portal. The drilling sleeve on the guide is placed on the superior aspect of the clavicle, centered anterior to posterior, whereas the aiming arm is positioned on the undersurface of the coracoid, centered medial to lateral (asterisk), in a left shoulder with the patient placed in the beach-chair position.

(Fig 4) to sit flush on the clavicle, reducing the risk of irritation of the overlying soft tissues. This must be centered on the clavicle. The central pin is removed from the drill, and a suture is passed through the cannulated drill through the clavicle and coracoid into the subcoracoid recess. The suture is then retrieved out the AIL portal with a suture grasper. The drill is removed, and the passing suture is used to shuttle the double-loaded knotless CC fixation device (Knotless AC TightRope device; Arthrex) in an antegrade direction through the transosseous clavicle and coracoid tunnels. A large cortical fixation button (Dog Bone; Arthrex) is then attached to the distal end of the knotless CC fixation device. The cortical button is positioned on the inferior aspect of the coracoid, and the sutures are pulled from the superior side to secure the cortical fixation button on the undersurface of the coracoid (Fig 5). The knotless fixation device is pulled securely until the clavicle is reduced fully. The suture ends may be clipped at this point or preserved for additional compression. Intraoperative fluoroscopy is used at this point to confirm the reduction.

Allograft CC Ligament Reconstruction

The knotless CC fixation can be augmented with a tibialis anterior allograft or a hamstring autograft. The graft can be placed arthroscopically around the undersurface of the coracoid and secured over the superior aspect of the distal clavicle. It is the senior authors' (P.J.M.) preference to use an additional soft-tissue graft fixation for any arthroscopically assisted AC reconstruction independent of the Rockwood grade or the chronicity of the injury. To pass the graft, a blunt switching stick is used to create 2 soft-tissue tunnels, one medial and the other lateral to the coracoid. The first tunnel is created by placing the switching stick posterior to the clavicle and medial to the coracoid in a superior-to-inferior direction through the soft tissues, stopping in the subcoracoid recess under arthroscopic visualization. This re-creates the orientation of the native conoid ligament. A soft-tissue dilator (Arthrex) is then placed over the switching stick, the switching stick is removed, and a rigid suture (FiberStick; Arthrex) is passed through the dilator and retrieved out the AIL portal, serving as a shuttling suture for subsequent graft

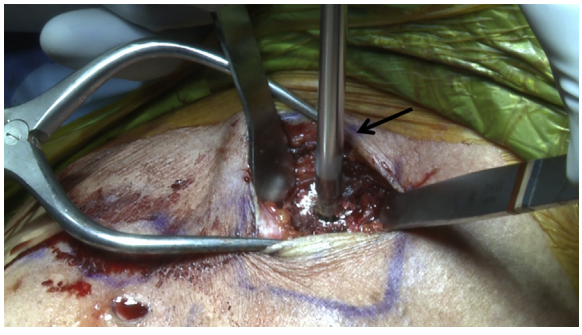

Fig 3. A unicortical reamer (arrow) is placed over the guide pin and is used to ream the superior cortex of the clavicle so that the top hat device sits flush on a left clavicle with the patient placed in the beach-chair position.

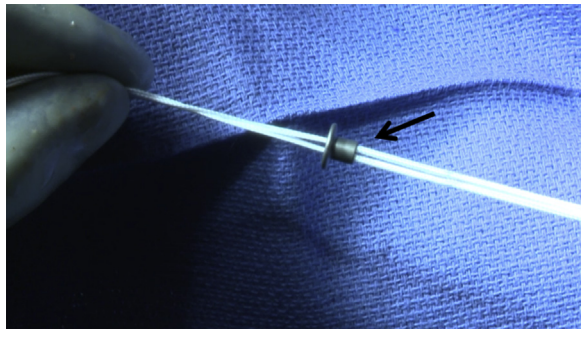

Fig 4. The knotless clavicle insert device with a double TightRope (arrow) is used to secure the Dog Bone to the undersurface of the coracoid in a left shoulder with the patient placed in the beach-chair position.

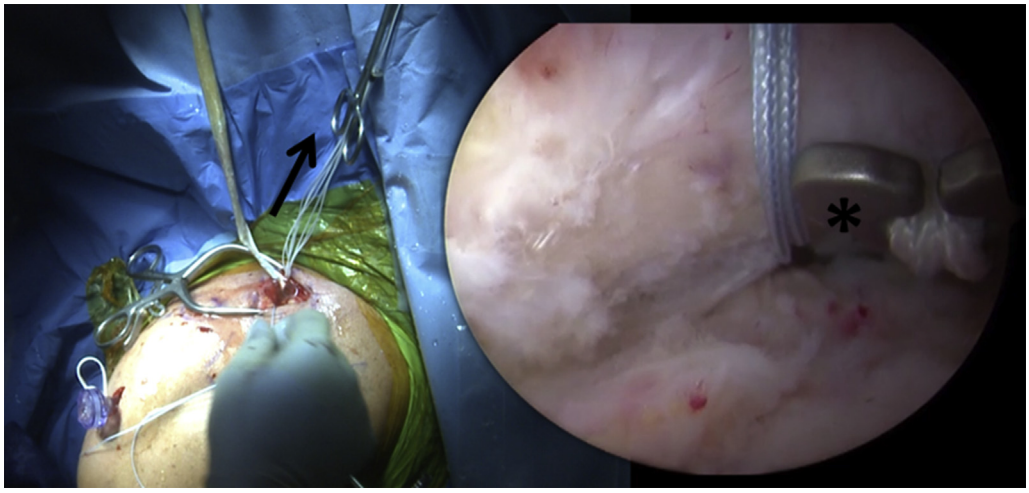

Fig 5. A cortical fixation button is attached to the distal end of the TightRope, and the TightRope is pulled from its superior end (arrow) to secure the Dog Bone on the undersurface of the coracoid (asterisk) in a left shoulder with the patient placed in the beach-chair position.

passage. The process is repeated; however, the second tunnel is started anterior to the clavicle exiting into the subcoracoid recess just lateral to the body of the coracoid. A second rigid passing suture is placed through the dilator and out the AIL portal.

At this point, the soft-tissue graft is passed around the clavicle and coracoid using the 2 passing sutures. One end of the graft is shuttled from superior to inferior by proceeding from posterior on the clavicle to medial on the coracoid, exiting through the AIL portal. This re-creates the conoid ligament. The graft is then shuttled from inferior to superior, moving from the AIL portal to the lateral aspect of the coracoid and exiting anterior to the clavicle using the previously placed passing suture. This re-creates the trapezoid ligament. In this way, the graft is looped around both the clavicle and coracoid to anatomically re-create the CC ligaments (Fig 6).

An inferiorly directed force is reapplied to the clavicle, and the CC fixation device can be re-tensioned, thus reducing the clavicle into anatomic position. Because the knotless CC fixation device is secured by a self-locking mechanism, no knots are required on the top of the clavicle. Each end of the graft is placed over the superior clavicle and secured with a simple overhand throw, which is then secured with nonabsorbable suture (Fig 7). Finally, the free ends of the graft are sharply cut.

Once the graft has been secured in place, the wound is copiously irrigated and closed in a layered fashion. Meticulous closure of the overlying deltotrapezial fascia is performed. A soft dressing is applied to the affected arm, followed by a sling. The pearls and pitfalls for this technique are outlined in Table 2.

Postoperative Rehabilitation

Immediately postoperatively, an abduction sling is applied for the first 4 to 6 weeks to reduce the tension on the reconstruction. Supine passive range-of-motion exercises are also started in this period. At 4 to 6 weeks postoperatively, active and active-assisted motion is

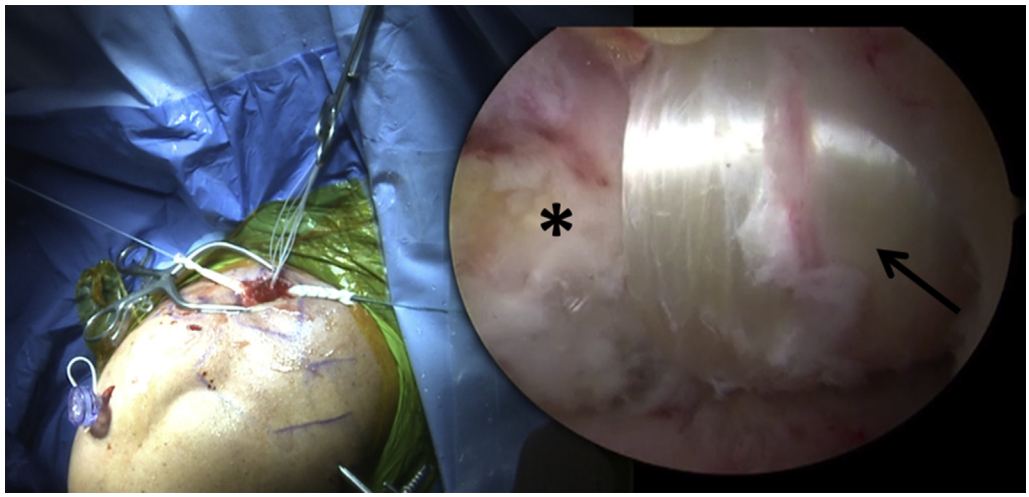

Fig 6. The allograft (arrow) is pulled around the inferior aspect of the coracoid (asterisk) to help augment the reconstruction in a left shoulder with the patient placed in the beach-chair position.

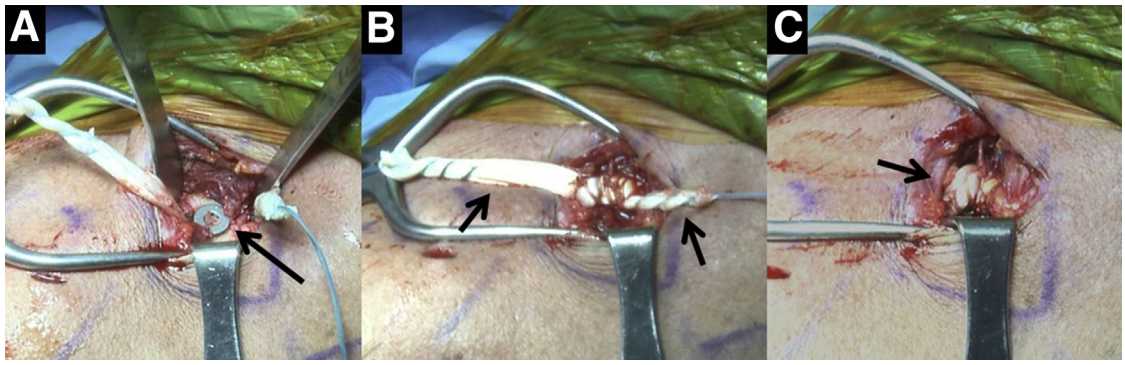

Fig 7. (A) The top hat construct (arrow) has been secured and the allograft passed around the coracoid. (B) The tails of each end of the allograft (arrows) are tied over the top hat. (C) The free ends are cut and the final construct is shown (arrow) in a left shoulder with the patient placed in the beach-chair position.

begun. Strengthening exercises are started at 8 weeks postoperatively. After approximately 16 weeks of rehabilitation, patients are allowed to return to full activities.

Discussion

To date, there is no gold-standard treatment for AC joint separations. Surgical treatment is acknowledged for the higher-grade Rockwood injuries type IV through VI and for patients with persistent symptoms and AC joint instability after nonoperative treatment of lower-grade AC joint injuries.[3,13] Open surgical treatment with the Weaver-Dunn procedure or hook-plate fixation is being replaced increasingly by arthroscopically assisted procedures. Arthroscopically assisted procedures have the potential advantages of a single-stage minimally invasive operation with better visualization and the possibility to diagnose and treat concomitant glenohumeral pathologies that are common in higher-grade lesions.

Although clinical outcomes for open and arthroscopic procedures have not been directly compared, more recent data have shown significantly higher quality of life after the minimally invasive arthroscopic procedures.[12] Minimally invasive anatomic reconstruction of the AC joint is technically challenging, with complication rates of 27% to 44% reported with initial surgical techniques.[5] Complications including fractures of the clavicle or coracoid process, loss of reduction, implant failure with suture rupture, caudal migration of the supraclavicular implants, and local soft-tissue pain due to hardware or suture irritation have led to a continuous development of arthroscopically assisted techniques and implants.

Early arthroscopic AC joint reconstruction techniques with intraosseous graft fixation or double suture-button devices were associated with higher-than-desired rates of clavicle and coracoid fractures.[1,6] Subsequently, more and/or larger drill holes were found to increase the risk of fracture by reducing the loads to failure of the clavicle and coracoid biomechanically.[6,8] Graft ruptures and implant failures with suture rupture and subsequent loss of reduction were other areas of concern.[4,14,15] Furthermore, osseous migration of small suture buttons was observed with first-generation implants.[1] These complications led to the development of larger suture-button devices with the use of wider and stronger suture tape that requires only a single drill hole.

Local hardware pain and irritation caused by the suture buttons and knots on top of the clavicle have been reported in up to 46% of cases.[12] A recent systematic review of arthroscopically assisted techniques found an overall rate of hardware irritation of 26.7%.[11] Cases of

Table 2. Pearls and Pitfalls

Pearls
Proper placement of the anteroinferolateral portal allows for direct access to the inferior aspect of the coracoid to pass the CC fixation device and the soft-tissue graft.
Placing the unicortical reamer over a guide pin allows placement of the superior cortical fixation device so that it sits flush with the superior clavicle.
Ensuring adequate soft-tissue tunnels both medial and lateral to the coracoid allows for easy passage of the graft.
Pitfalls
Improper suture management while passing the CC fixation device and/or graft should be avoided.
The surgeon should make sure the drill is centered on the superior aspect of the clavicle and the reamer will not ream out the anterior or posterior cortices of the clavicle if the drill is placed eccentrically.
Failure to clear soft tissue from the subcoracoid recess should be avoided.

CC, coracoclavicular.

Table 3. Advantages and Limitations

Advantages
Knotless, low-profile, strong initial fixation with a reduced risk of fractures because of smaller tunnels and purposely designed cortical fixation buttons
Use of an additional soft-tissue graft provides greater stability and allows for biological ligament reconstruction
Anatomic reconstruction
Limitations
High technical demand and steep learning curve
Long-term outcomes of this technique not well documented

revision surgery with implant and suture removal have been described.[14]

Postoperative loss of reduction has been reported with most surgical techniques of AC joint reconstruction ever since their introduction.[6,12] Many authors advocate the use of suture-button devices only for the stabilization of acute AC joint injuries and the use of soft-tissue graft techniques for chronic cases.[14] Recently, an additional temporary pin fixation has been reported to provide more initial stability.[15] The senior surgeon (P.J.M.), however, uses an additional soft-tissue graft to provide higher initial stability even in acute cases.[9]

The surgical technique described in this technical note combines the potential advantages of single bone tunnel drilling with minimal bone removal, strong initial fixation, and a low-profile knotless fixation device (Table 3). The goal of this procedure is to provide good to excellent clinical outcomes with lower complication rates than previously associated with other open and arthroscopic surgical techniques. Future research is warranted to investigate if these theoretical advantages will lead to improvements in clinical outcomes and reduced complication rates. Thus far, clinical results have matched the promise of the improved implant design and surgical technique.

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