**Technical Note**

**Modified Shelf Acetabuloplasty Endoscopic Procedure With Allograft for Developmental Hip Dysplasia Treatment**

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**Abstract:** Hip dysplasia has been identified as one of the leading causes of osteoarthritis. However, hip arthroscopy alone, in the setting of hip dysplasia, remains controversial. In borderline hip dysplasia, with lateral center-edge angle (LCEA) between 18° and 25°, good outcomes have been reported with appropriate capsular and labral management. However, in severe hip dysplasia, with LCEA below 18°, there is an acetabular bony structural deficiency that must be addressed. Even with the potential benefit of hip arthroscopy in addressing intra-articular injuries related to the instability, it cannot be used for soft-tissue procedures. Periacetabular osteotomy remains the gold standard to address that matter; however, its invasive nature along with the long recovery time leaves some patients unwilling to undergo this procedure. New minimally invasive endoscopic procedures, derived from open techniques, describe acetabular autologous bone grafting as an alternative. Donor-side morbidity is always a concern when using autografts; we believe that the use of bone allograft will decrease this potential issue and make the procedure itself less invasive. This Technical Note will describe a type of endoscopic shelf acetabuloplasty using an allograft iliac bone graft.

The shelf procedure is not new; it is in fact the oldest procedure for acetabular dysplasia treatment. It was first described by König in 1891 and modified and popularized by Gill in 1926. Afterwards, Wiberg improved the technique and the results of the procedure, with the operative aim to stabilize movement of the femoral head by increasing the acetabular coverage in the weight-bearing position.

The advent of the periacetabular osteotomy (PAO), described by Ganz et al., was a “game changer” in the treatment of the developmental dysplasia of the hip (DDH) in the young and active patient. Albeit a more complex and technically demanding surgery, it tends to yield good results at long-term follow-up. However, intra-articular pathology is common in the dysplastic patient, and a failure to address these potential pain sources could be a major factor in failures or revision rates. Different investigators have described the possibility of concomitant PAO and hip arthroscopy with the objective of combining the advantages of both techniques, bone and intra-articular corrections, in a single surgical time. Nevertheless, PAO alone or with the addition of hip arthroscopic surgery remains a challenging procedure, and experienced hands are needed to avoid catastrophic complications. In addition, long recovery periods may be unappealing for some patients.

In a pursuit of more minimally invasive options that still can correct bony acetabular deficient (Fig 1) and intra-articular joint pathology, Uchida et al. recently reignited interest in the shelf procedure but used endoscopic techniques and an iliac crest autograft. We describe our shelf technique with 2 important variations: first, using bone allograft in order to avoid...
potential donor-side morbidity risk and second, using cannulated screws for graft stabilization (Video 1).

Surgical Technique

Patient Positioning

Preoperative preparation begins with placing the patient in the modified supine position on the Advanced Supine Hip Positioning System (Smith and Nephew, London, UK), in slight Trendelemburg with a well-padded perineal post. Traction is implemented when necessary.

Arthroscopic Access and Portal Placement

A spinal needle is introduced into the joint to vent and allow for distraction. Traction is first applied to the nonoperative leg and then applied as needed to the operative leg at a maximum of 50 pounds. The hip joint is accessed through the anterolateral, midanterior, and distal anterolateral accessory (DALA) portals as described by Domb et al.14 An interportal capsulotomy is created between the standard anterolateral and midanterior portals with a 4-mm Arthro-Lok Banana beaver blade (Beaver-Visitec International, Waltham, MA).

Diagnostic Arthroscopy

A systematic diagnostic arthroscopy is performed with a 70° Direct View Arthroscope (Smith and Nephew) and a 4.8 mm hook tip probe (Arthrex, Naples, FL). The ligamentum teres, acetabular notch, iliopsoas impingement sign, labral and chondrolabral junction conditions, and acetabular and femoral head cartilage are assessed (Fig 2).

Initial Capsular Management

Capsular management is vital. An effort to preserve capsular tissue is made throughout the entire case. Using a 3-mm 50° radiofrequency wand (Smith and

Fig 1. Anteroposterior pelvis preoperative x-ray. Right side (R) shows true acetabular dysplasia with a lateral center-edge angle (LCEA) of 15°.

Fig 2. Right hip, supine position, 70° arthroscope, arthroscopic view from anterolateral portal, probe from anterior portal. A, acetabulum; FH, femoral head; L, labrum.

Fig 3. Right hip, supine position, 70° arthroscope, arthroscopic view from anterolateral portal after labral repair. A, acetabulum; L, labrum.

Fig 4. Right hip, supine position, 70° arthroscope, arthroscopic view from anterolateral portal, shaver from anterior portal. C, capsule; FH, femoral head; L, labrum. “Suction seal” restored, and capsular tissue preserved.
Nephew), capsular elevation from the acetabular side is performed in order to get the best exposure possible for anchor placement prior to labral repair. To improve visualization, SlingShot Suture Managers (Pivot Medical, Sunnyvale, CA) are used to pierce the acetabular capsule cuff and put a traction stitch with a no. 2 Fiber Wire (Arthrex).

Labral Assessment and Repair

No trimming of the acetabular rim is indicated. The cortical bone is refreshed to ensure proper healing of labral repair with a motorized 5.5-mm round burr (Smith and Nephew). Knotless SutureTak anchors (Arthrex) are placed through the distal accessory portal with 6 to 8 mm of spacing for labral repair using a looped technique with a Nanopass Suture Management System (Pivot Medical; Figs 3 and 4).

Femoral Osteochondroplasty

For assessment and treatment of cam deformities, traction is released. A traction stitch is placed in the inferior capsule with a SlingShot Suture Manager, and a no. 2 Fiber suture is passed, allowing full exposure of the peripheral compartment without the necessity of a “T” capsulotomy. A cam osteochondroplasty is performed using a motorized round burr.

Capsular Plication

At 45° of hip flexion, the capsule is plicated with 6 no. 2 Vicryl sutures (Ethicon, Somerville, NJ). SlingShot Suture Manager is used to pierce the superior and inferior capsular cuffs. Knot tying is done after all sutures are passed.23

Graft Preparation

To avoid donor-site morbidity, an iliac wing bone allograft is selected. The graft size is prepared to 10 mm in width and 20 mm in depth with an additional 3 x 7 mm tapered wing wedge created at the superior...
aspect. This wing will mate with a trough created along the anterior acetabular rim (Fig 5).

**Endoscopic Stage**

By combined use of a 4-mm shaver (Smith and Nephew) and a 3-mm 50° radiofrequency device, a working space is created between the reflected head of the rectus and the anterior acetabular rim to assist in further graft placement. Proper location of the space is confirmed by the use of fluoroscopy (Fig 6). Decortication of the space is performed with a 5-mm burr. A 10-mm osteotome is introduced through the DALA portal, and a trough measuring approximately 10 mm wide and 20 mm deep is created, similar to the method described by Uchida et al.22 The trough is deepened at the superior aspect to create space for 3/7 mm wing wedge fabricated on the allograft bone graft.

Two parallel 1.25-mm threaded guide wires (DePuy-Synthes, West Chester, PA) are passed through the graft (Fig 7), and the graft itself goes through the DALA portal. Adequate position and orientation of the graft is confirmed via combined arthroscopic and fluoroscopic views. Once the position is confirmed, both 1.25-mm threaded guide wires are advanced to the previously created bone slot, and final fixation is achieved with 2 partially threaded 3.5-mm cannulated screws (DePuy-Synthes; Figs 8 and 9).

**Postoperative Rehabilitation**

After surgery, the patient is placed in a brace (Donjoy X-Act ROM Hip Brace, Vista, CA) for 6 weeks in order to protect the hip and limit abduction and rotation. Gentle passive range-of-motion exercise is initiated during the first week under the supervision of a physiotherapist. During the first 6 weeks, the patient remains in 20 pounds of flat foot partial weight bearing. Active hip flexion is not allowed until week 6, and from then weight bearing is gradually increased. Full weight bearing is allowed at 8 weeks after surgery.

**Discussion**

We present our endoscopic technique for the shelf acetabular procedure for the management of developmental hip dysplasia in the young and active adult. In the pursuit of a more minimally invasive procedure, we use an iliac wing bone allograft to avoid potential donor-side morbidity.24 To improve fixation stability we also added the use of cannulated screws.

Our current indications and contraindications are reflected in Table 1. Currently in our clinical practice, PAO with concomitant hip arthroscopy is our gold standard for DDH treatment of the young adult.18 The endoscopic shelf procedure is offered as an alternative

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**Table 1. Surgical Indications and Contraindications**

| Indications                              | Contraindications                               |
|------------------------------------------|------------------------------------------------|
| Hip pain                                 | Severe dysplasia, LCEA < 12°                   |
| Positive anterior and posterior impingement tests | Advanced osteoarthritis                       |
| LCEA between 12° and 20°                | Associated severe skeletal abnormalities (perthes, coxa magna, slipped capital femoral epiphysis) |
| MRA evidence of a labral tear           | Active infection                               |
| No evidence of severe chondral damage evidence on dGEMRIC MRA | Skeletally immature patients (age < 12 years) |
| Tönnis grade 0 or 1                     | Bipolar and severe chondral damage             |

*dGEMRIC, delayed contrast-enhanced magnetic resonance imaging of cartilage; LCEA, lateral center-edge angle; MRA, magnetic resonance arthrography.

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**Table 2. Advantages and Disadvantages**

| Advantages                          | Disadvantages                           |
|-------------------------------------|-----------------------------------------|
| Arthroscopic visualization          | Steep learning curve                    |
| Treatment of concomitant pathologies such labral tears, femorocacetabular impingement, iliopsoas impingement | Meticulous technique                   |
| No donor-side morbidity             | Not applicable for severely dysplastic patients |
| Minimally invasive surgery          | Lack of long-term follow-up             |

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**Table 3. Pearls and Pitfalls**

| Pearls                                          | Pitfalls                                      |
|-------------------------------------------------|-----------------------------------------------|
| Intra-articular work is done first.             | Does not address associated intra-articular pathologies. |
| Labral functional preservation, through repair or reconstruction | Labral debridement                            |
| Preserves the capsule for further capsular plication. | Inadequate capsular management: capsulectomy or nonplication |
| Fluoroscopy use during the case                 | Improper placement of the allograft           |

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Fig 9. Anteroposterior pelvis postoperative x-ray showing final result on the right (R) hip.
treatment for patients who meet those indications and do not want to proceed with PAO. Even with the potential advantages involved in this minimal invasive surgery (Table 2), we believe that more high-quality studies with follow-up are needed prior to recommending the shelf procedure as an equal surgical alternative to PAO. Pearls and Pitfalls are shown in Table 3. Acknowledging the demanding nature of this endoscopic procedure, the risks must be recognized and considered (Table 4). When incorporating time-consuming arthroscopy techniques to address intra-articular pathologies to the operation, extravasation is a vital concern.25-27 The surgeon must also factor in other previously reported potential complications inherent in hip arthroscopy.28-30

References
1. Fawzy E, Mandellos G, De Steiger R, McLardy-Smith P, Benson MKD, Murray D. Is there a place for shelf acetabuloplasty in the management of adult acetabular dysplasia? A survivorship study. J Bone Joint Surg Br 2005;87:1197-1202.
2. Holm AGV, Reikerås O, Terjesen T. Long-term results of a modified Spitz operation for residual hip dysplasia and subluxation. A fifty year follow-up study of fifty six children and young adults. Int Orthop 2017;41:415-421.
3. Wilberg G. Shelf operation in congenital dysplasia of the acetabulum and in subluxation and dislocation of the hip. J Bone Joint Surg Am 1953;35:65-80.
4. Ganz R, Klaue K, Vinh TS, Mast JW. A new periacetabular osteotomy for the treatment of hip dysplasia. Technique and preliminary results. Clin Orthop 1988;232:26-36.
5. Lerch TD, Steppacher SD, Liechti EF, Siebenrock KA, Tannast M. [Bernese periacetabular osteotomy: Indications, technique and results 30 years after the first description]. Orthopade 2016;45:687-694.
6. Steppacher SD, Tannast M, Ganz R, Siebenrock KA. Mean 20-year followup of Bernese periacetabular osteotomy. Clin Orthop 2008;466:1633-1644.
7. Domb BG, Lareau JM, Baydoun H, Botser I, Millis MB, Yen Y-M. Is intraarticular pathology common in patients with hip dysplasia undergoing periacetabular osteotomy? Clin Orthop 2014;472:674-680.
8. Redmond JM, Gupta A, Stake CE, Domb BG. The prevalence of hip labral and chondral lesions identified by method of detection during periacetabular osteotomy: arthroscopy versus arthrotomy. Arthroscopy 2014;30:382-388.
9. Cvetanovich GL, Heyworth BE, Murray K, Yen Y-M, Kocher MS, Millis MB. Hip arthroscopy in patients with recurrent pain following Bernese periacetabular osteotomy for acetabular dysplasia: operative findings and clinical outcomes. J Hip Preserv Surg 2015;2:295-302.
10. Hartig-Andreasen C, Troelsen A, Thillemann TM, Gelineck J, Soballe K. Risk factors for the need of hip arthroscopy following periacetabular osteotomy. J Hip Preserv Surg 2015;2:374-384.
11. Fujii M, Nakashima Y, Noguchi Y, et al. Effect of intraarticular lesions on the outcome of periacetabular osteotomy in patients with symptomatic hip dysplasia. J Bone Joint Surg Br 2011;93:1449-1456.
12. Uchida S, Utsunomiya H, Mori T, et al. Clinical and radiographic predictors for worsened clinical outcomes after hip arthroscopic labral preservation and capsular closure in developmental dysplasia of the hip. Am J Sports Med 2016;44:28-38.
13. Chandrasekaran S, Darwish N, Martin TJ, Suarez-Ahedo C, Lodhia P, Domb BG. Arthroscopic capsular plication and labral seal restoration in borderline hip dysplasia: 2-year clinical outcomes in 55 cases. Arthroscopy 2017;33:1332-1340.
14. Domb BG, Stake CE, Lindner D, El-Bitar Y, Jackson TJ. Arthroscopic capsular plication and labral preservation in borderline hip dysplasia: two-year clinical outcomes of a surgical approach to a challenging problem. Am J Sports Med 2013;41:2591-2598.
15. Evans PT, Redmond JM, Hammarstedt JE, Liu Y, Chaharbakhshi EO, Domb BG. Arthroscopic treatment of hip pain in adolescent patients with borderline dysplasia of the hip: minimum 2-year follow-Up. Arthroscopy 2017;33:1530-1536.
16. Domb BG, Philippou MJ, Giordano BD. Arthroscopic capsulotomy, capsular repair, and capsular plication of the hip: relation to atraumatic instability. Arthroscopy 2013;29:162-173.
17. Kim K-I, Cho Y-J, Ramteke AA, Yoo M-C. Peri-acetabular rotational osteotomy with concomitant hip arthroscopy for treatment of hip dysplasia. J Bone Joint Surg Br 2011;93:732-737.
18. Domb BG, LaReau JM, Hammarstedt JE, Gupta A, Stake CE, Redmond JM. Concomitant hip arthroscopy and periacetabular osteotomy. Arthroscopy 2015;31:2199-2206.
19. Goronzy J, Franken L, Hartmann A, et al. What are the results of surgical treatment of hip dysplasia with concomitant cam deformity? Clin Orthop 2017;475:1128-1137.
20. Coobs BR, Xiong A, Clohisy JC. Contemporary concepts in the young adult hip patient: periacetabular osteotomy for hip dysplasia. J Arthroplasty 2015;30:1105-1108.
21. Pascual-Garrido C, Harris MD, Clohisy JC. Innovations in joint preservation procedures for the dysplastic hip “the periacetabular osteotomy.” J Arthroplasty 2017;32: S32-S37.
22. Uchida S, Wada T, Sakoda S, et al. Endoscopic shelf acetabuloplasty combined with labral repair, cam osteochondroplasty, and capsular plication for treating developmental hip dysplasia. Arthrosc Tech 2014;3:e185-e191.
23. Chandrasekaran S, Vemula SP, Martin TJ, Suarez-Ahedo C, Lodhia P, Domb BG. Arthroscopic technique of capsular plication for the treatment of hip instability. Arthrosc Tech 2015;4:e163-e167.
24. Barbour SA, King W. The safe and effective use of allograft tissue—an update. *Am J Sports Med* 2003;31:791-797.

25. Ekhtiari S, Haldane CE, de Sa D, Simunovic N, Ayeni OR. Fluid extravasation in hip arthroscopy: a systematic review. *Arthroscopy* 2017;33:873-880.

26. Hinzpeter J, Barrientos C, Barahona M, et al. Fluid extravasation related to hip arthroscopy: a prospective computed tomography-based study. *Orthop J Sports Med* 2015;3. 2325967115573222.

27. Kocher MS, Frank JS, Nasreddine AY, et al. Intra-abdominal fluid extravasation during hip arthroscopy: a survey of the MAHORN group. *Arthroscopy* 2012;28:1654-1660.e2.

28. Papavasiliou AV, Bardakos NV. Complications of arthroscopic surgery of the hip. *Bone Joint Res* 2012;1:131-144.

29. Domb BG, Domb B, LaReau J, Redmond JM. Combined hip arthroscopy and periacetabular osteotomy: indications, advantages, technique, and complications. *Arthrosc Tech* 2014;3:e95-e100.

30. Nakano N, Lisenda L, Jones TL, Loveday DT, Khanduja V. Complications following arthroscopic surgery of the hip: a systematic review of 36 761 cases. *Bone Joint J Br* 2017;99:1577-1583.