Technical Note

Young Bovine Hip Model for Hip Arthroscopy Training

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Abstract: Hip arthroscopy is associated with risks for complications, especially for novice surgeons. The present article reports use of a young bovine hip as a valid educational tool for key components of arthroscopic treatment of femoroacetabular impingement syndrome, ie, labrum repair and cam excision. The purpose of this Technical Note is to describe the steps of arthroscopic femoroacetabular impingement treatment in the bovine hip.

Although hip arthroscopy has gained popularity, with an 85% increase in its use in the last decade, there is still a steep learning curve.[1] A wide range exists concerning the cut-off number that is required to attain proficiency to decrease complication rates, surgical traction time, and reoperation rates, as well as to improve patient-reported outcomes. It is reported to vary between 20 to more than 500 cases.[2] The best way is to train and gain experience with hip joints is from the use of a human cadaver; however, there exists substantial barriers such as the cost of the tissue, ethical issues, and storage.[3-5] Recent studies advocated the use of dry models or virtual hip arthroscopy simulators to overcome this learning curve, with variations in reported learning.[6-9] However, the ability of these models to mimic real-life conditions is limited due to texture of muscles, dilatation of tissues due to water inflow, and moreover, learning the establishment of portals is impossible based upon already-existing portals.[8] Most recently, automated visualization tools have been advocated to be used intraoperatively for novice surgeons to prevent both over- and under-resection of cam lesion.[10,11]

As bovine knee has been validated to be used to improve surgical skills,[12] bovine labrum has been reported to have similar biomechanical properties compared with its human counterpart,[13-15] and bovine proximal femur has natural cam morphology (Fig 1), the present study aimed to clarify young bovine hip as an effective education tool, especially for key parts such as labrum repair and cam excision in arthroscopic impingement treatment.[16]

Surgical Technique (With Video Illustration)

Specimen Preparation and Positioning

Fresh 6-month-old bovine left hemipelvis with femur and tibia and attached muscles are obtained from a local abattoir or slaughterhouse (Table 1). Schanz screws are applied through the ilium, distal femur, and distal tibia later for traction application. A horseshoe apparatus is used at ilium and distal tibia for the ease of traction (Fig 2).

Distal tibia traction is applied at medial side of specimen to mimic adduction vector. Approximately 2 cm above the tip of the greater trochanter, primarily the trajectory of the needle is checked using fluoroscopy guidance. As 1 cm of joint distraction was evident on fluoroscopy, an anterolateral portal is created first under the guidance of radiographs. Subsequently, the anteromedial portal, which was lateral to the line connecting the knee to the anterior superior iliac spine, is created under direct visualization with rod passing through the triangle formed by anterior

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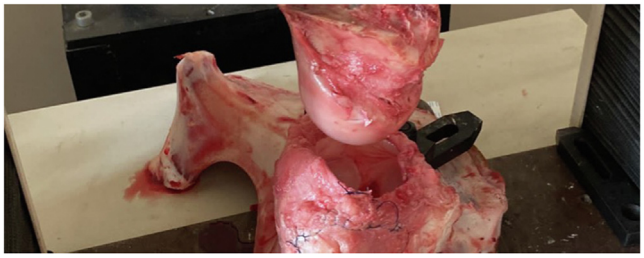

Fig 1. Adult bovine left hip with cam deformity at superior part of the left femur.

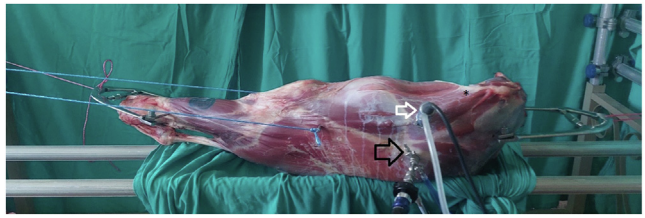

Fig 2. Bovine left hip specimen with traction applied from the ilium, distal tibia, and distal femur. Anteromedial (white arrow) and anterolateral portals (2 cm proximal to tip of the greater trochanter, ie, "black arrow") are seen. *Anterior superior iliac spine.

labrum, femoral head, and the hip capsule (Figs 2 and 3, Video 1).

Central Compartment Arthroscopy

First, visualizing through the anterolateral portal and using the beaver blade (Mitek Sports Medicine, Raynham, MA) from the anteromedial portal, the hip capsule is cut from medial to lateral. Then, switching between portals, in other words visualizing through the anteromedial portal and working through the anterolateral portal, the remaining capsule tissue is cut and interportal capsulotomy is completed (Fig 4). Afterward, via visualization through anterolateral portal, approximately 2 cm of labrum tear is created at anterior portion of acetabulum using the beaver blade (Fig 5).

Before the labrum repair, via working through the anteromedial portal, using the attachment side of the labrum at capsular site as a landmark, the capsule is elevated 0.5 cm proximally. A bony bed is then prepared using a 4.5-mm burr (Conmed Linvatec, Largo, FL) and radiofrequency (Tulparmed, Ankara, Turkey) clearing the soft tissue and smoothening the bony edge (Video 1). A 2-cm-long labral tear is created through the anteromedial portal using the beaver blade extending from anteromedial to posterolateral. Then, a 3-mm double-loaded titanium anchor (Tulparmed) is deployed through the anteromedial portal at the midpart of the tear at the 10:30-o'clock position, 3 to 4 mm away from the labrum with direct visualization of the joint to prevent iatrogenic penetration. Double-loop repair of the labrum is then performed using a bird beak, passing the suture through the chondrolabral junction and grabbing it around the labrum. A sliding

Table 1. Surgical Steps in the Young Bovine Hip Model

Surgical Steps
1. Obtain fresh 6-month-old bovine hemipelvis including tibia and femur with attached muscles.
2. Defrost for at least 1 day and test it by measuring the flexibility of hip joint.
3. Place the specimen on a radiolucent table.
4. Apply traction through the ilium and through femur and tibia.
5. Check at least 1 cm of traction is evident on radiograph.
6. Place anterolateral portal 2 cm proximal to greater tuberosity with trajectory determined on fluoroscopy to try to be parallel to floor and acetabulum sourcil.
7. Place the anteromedial portal at same level with the anterolateral portal and lateral to the line connecting the anterior superior iliac spine to knee, under direct visualization through anterolateral portal.
8. Perform interportal capsulotomy switching between portals.
9. Prepare acetabular rim and elevate the capsule at anterior zone of acetabulum.
10. Create 2 cm labral tear between the 9-o'clock to 11-o'clock positions.
11. Place double-loaded anchor through anteromedial portal at 10:30-o'clock position and perform loop repair using the bird beak.
12. Gradual cam excision starting from anteromedial part when hip is flexed to 45° to posterolateral part by achieving hip extension.
13. Check the cam lesion correction on Dunn 45° view.

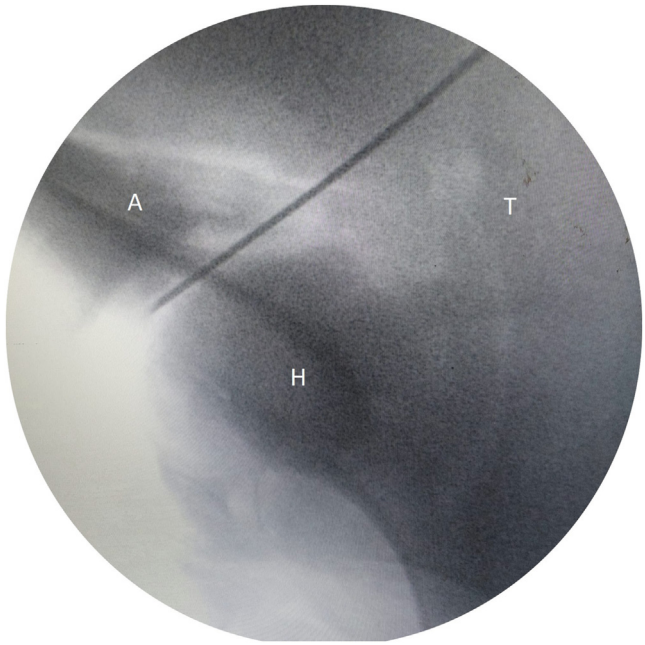

Fig 3. Fluoroscopic view of the cannulated needle at the joint after traction is applied. (A, acetabulum; H, femoral head; T, trochanter.)

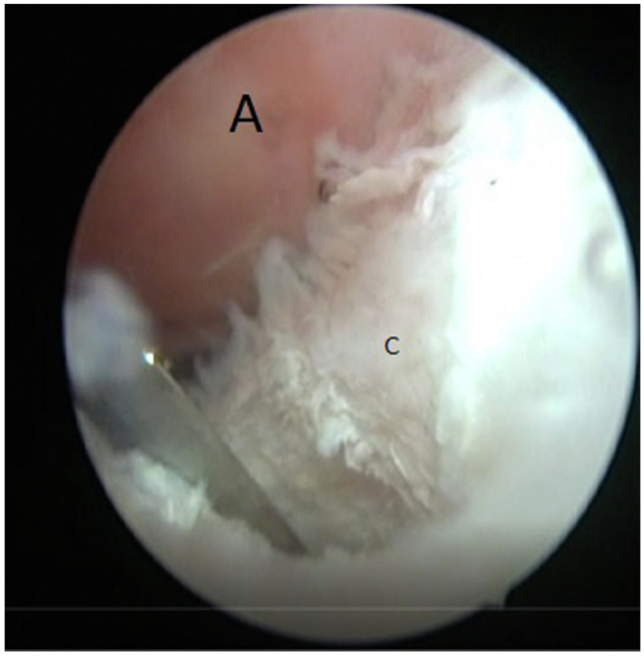

Fig 4. Left hip, viewing through the anterolateral portal, interportal capsulotomy is done using the beaver blade through the anteromedial portal. (A, acetabulum; C, capsule.)

knot with 4 additional half-hitches is then administered using the free suture arm as post to keep the knot away from the joint.[17] Ultimately, the stability of the repair is checked (Fig 6).

Peripheral Compartment Arthroscopy

Traction is then released. Under visualization through the anteromedial portal and working through the anterolateral portal, the extent of cam lesion is delineated through manipulating the hip from extension and internal rotation to 45° of hip flexion and neutral rotation. The most medial side of the cam lesion is excised with 45° of hip flexion. Later, excision of posterolateral extent of the cam lesion is performed when the hip is in extension (Fig 7), with simultaneous aid of fluoroscopy and checked ultimately on Dunn 45° view (Fig 8).

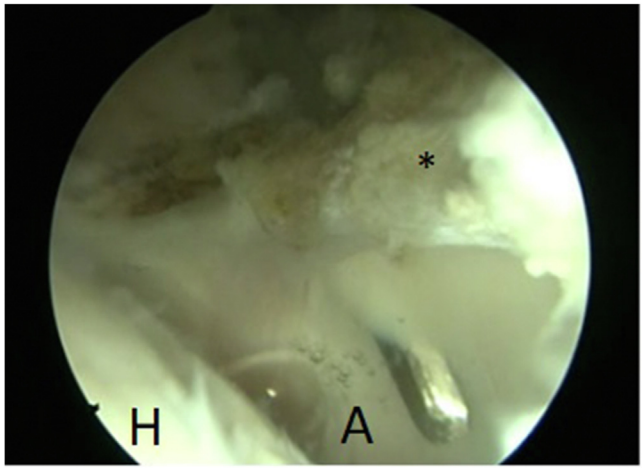

Fig 5. Left hip, visualization through the anterolateral portal, labral tear is created at the anterior portion of acetabulum using the beaver blade through the anteromedial portal. *Labrum. (A, acetabulum; H, femoral head.)

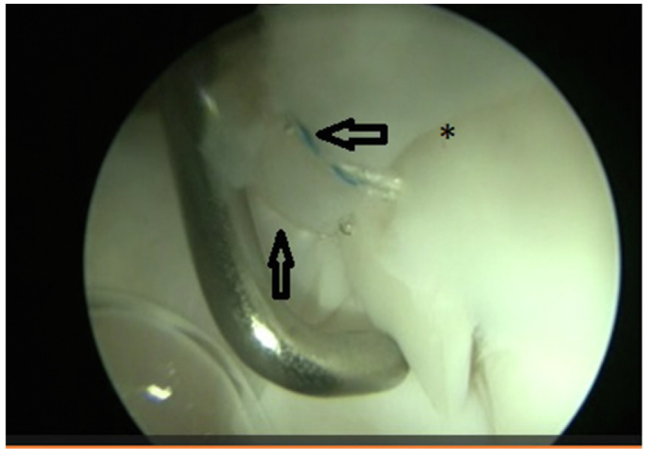

Fig 6. Left hip, visualization through the anterolateral portal, the stability of loop repair is checked with a probe passed through the anteromedial portal. Black arrows indicate sutures passed around the labrum. *Chondrolabral junction.

Discussion

As mentioned, there is a steep initial learning curve and there is high variability in the cut-off number regardig the number of patients needed to enhance outcomes, but in addition to this initial curve, reoperation risk also depends on the surgeon's total and/or annual volume of cases performed or, in another words, whether one is a high-volume surgeon.[18] As a practice tool, the bovine knee model has been validated previously.[12] In the present study, the hip model also has been validated, especially for the 2 key components of the arthroscopic treatment of FAI syndrome, which are reported to be the cam excision and labrum repair, according to a recent expert opinion survey of high-volume surgeons.[16]

However, some important points have to be mentioned. Adequate traction is mandatory. For achievement of this, counter traction was applied using the horseshoe apparatus, one through the ilium and two from distal, involving distal tibia traction having the adduction vector (Fig 2). This system also allowed us to use fluoroscopy easily. At least 1 day of defrosting the knee is necessary for the ease of traction, and due to young (6 months) bovine tissue having similar dimensions as human tissue, this enabled easy traction. However, because of that or due to nature of the bovine

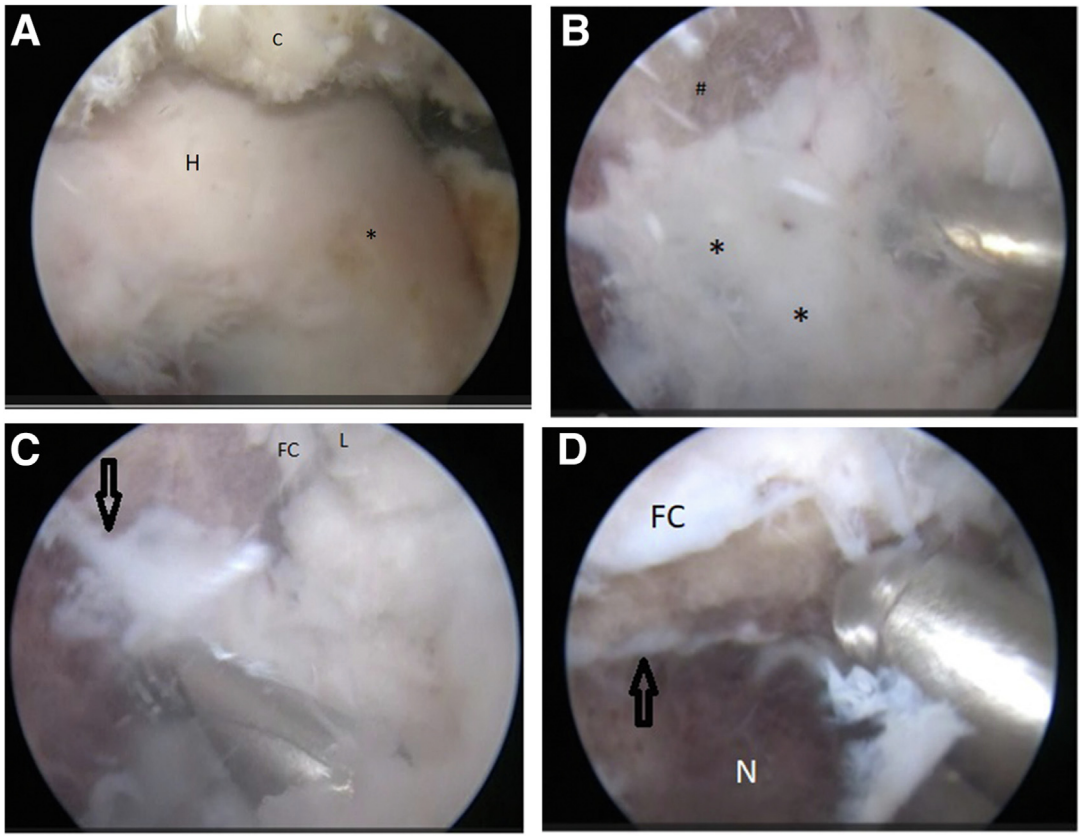

Fig 7. (A) Left hip, viewing from the anteromedial portal, and working through the anterolateral portal, cam lesion is confirmed when hip is flexed to 45°. *Cam lesion. (B) Cam excision is performed by working through the anterolateral portal. #Cam lesion has been removed and subchondral bone is exposed. *Remaining cam lesion. (C) Cam excision is extended by working through the anterolateral portal. Arrow: physis at the head–neck junction. (D) Cam excision completion by working through the anterolateral portal. Arrow: physis at the head–neck junction. (C, capsule; FC, femoral head cartilage; H, femoral head; L, labrum; N, femoral neck.)

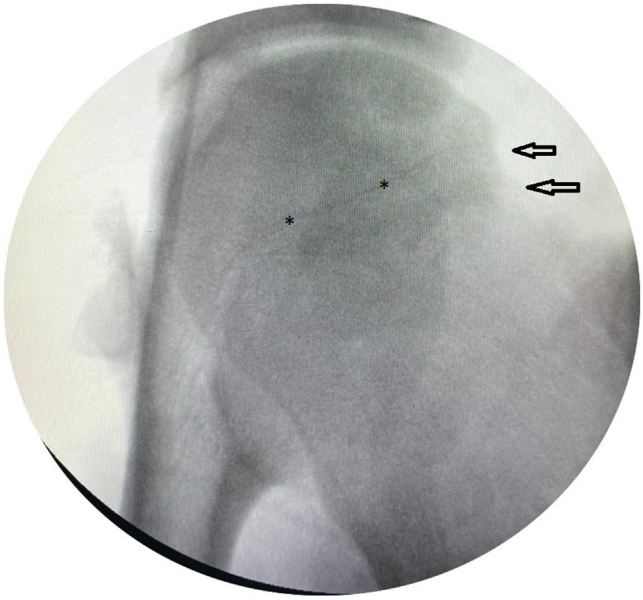

Fig 8. Last 45° Dunn radiograph view of the left hip after completion of the cam excision. Arrows: Cam lesion removed at the anterior part of the head–neck junction. *Physis.

tissue, the bony acetabulum was not as hard as human tissue, anchor was easily deployed with manuel pressure, and during bony preparation with the burr, we did not have the sensation as hard as human bone (Table 2). However, as shown in Figure 5, with a 2-mm tipped probe, the labrum size is similar to that of the human labra (4-5 mm).

Second, we performed cam excision at 45° of flexion and neutral rotation and checked under fluoroscopy Dunn 45° view. This single position may not be fully applicable to its human counterpart, although it hs been shown in clinical studies that it better provides visualization of anterior head–neck junction, where most cam lesions are localized.[19]

In conclusion, due to ease of obtaining the bovine tissue and handling of the specimen in regards to having a similar size with human tissues being due to younger age, the presented technique is thought to be valid for the use as an education tool and decrease the steep learning curve of arthroscopic hip surgery for novice surgeons.

Table 2. Pearls and Pitfalls

Pearls	Pitfalls
Adequate traction (at least 1 cm on radiograph): counter traction (one at ilium, one at femur, one at tibia)	Old or bigger animal, inadequate defrost, no adduction vector
Acetabulum rim prepare	Relatively soft bone; easy for anchor to deploy
Capsule excision, visualize cam lesion	Synovium, capsule remnants

Disclosure

All authors (O.H., S.A., M.O., B.Y., O.G., E.K.A.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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