Technical Note

Arthroscopic Fixation With Absorbable Suture Anchors for Pipkin Type I Femoral Head Fractures—Letter V Technique

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Abstract: Femoral head fractures are relatively uncommon high-energy injuries and usually associated with traumatic hip dislocation. Pipkin classified these fractures into 4 types according to the location of the head fragment related to the fovea and associated lesions on the femoral neck or acetabulum. Traditional open reduction and internal fixation for femoral head fracture has been proven to be effective, but it could be associated with significant complications. Arthroscopic fixation with screws is a less-invasive alternative to open reduction and internal fixation that offers several advantages. However, technical challenges could be encountered during the procedure and catastrophic consequences could occur in cases of fixation failure. Therefore, we propose an effective arthroscopic technique for Pipkin type I (small fracture caudal to the fovea capitis) femoral head fractures that uses an absorbable suture anchors. The anchors provide initial stability to the fracture fragments, and then the sutures are tied in a double-pulley fashion to further secure the fracture. Finally, a triangular suture bridge ("letter V") is created, which supplies a convenient and stable fixation for proper femoral head fracture.

The femoral head fracture is a relatively rare type of fracture in clinical practice, most often caused by high-violence injuries and often complicated by hip dislocation and acetabular fracture. The Pipkin classification describes forms of isolated femoral head fractures according to the location of the head fragment related to the fovea and associated lesions on the femoral neck or acetabulum.[1] Pipkin type I involves the fracture caudal to the fovea capitis, type II affects the fracture cephalad to the fovea capitis, type III includes types I or II with a femoral neck fracture, and type IV involves type I or II associated with acetabular fracture (Fig 1). As an intra-articular fracture, displaced fracture fragments may cause painful locking of the joint, leading to traumatic arthritis. Reduction of the fracture fragments and good immobilization are essential to maintain joint function.[2,3] The traditional surgical treatment of femoral head fracture is mainly open reduction and metal screw fixation. This method has been proven to be effective but also carries a high risk of complications, such as femoral head necrosis, heterotopic ossification, and arthritis.[4-6] With the development of arthroscopic surgery, arthroscopic-assisted internal fixation with metal screws recently has been reported for the treatment of femoral head fractures (Pipkin type I or II) with satisfactory results.[7] However, because of the lack of specialized instruments and the blockage of muscle tissue, operational difficulties may be encountered during the procedure. In the event that internal fixation fails and the metal implant loosens or breaks, the consequences will be devastating. Therefore, we proposed an effective technique using resorbable suture anchors to stabilize femoral head fractures by penetrating the fracture fragment and knotting it in a double-pulley fashion to form a triangle fixation-letter V technique. Video 1 describes the details of this technique.

Surgical Technique

A comprehensive radiographic evaluation should be performed before the surgery (Fig 2).

Anesthesia and Positioning

The surgery is performed with the patient under general anesthesia. The patient is placed in the supine

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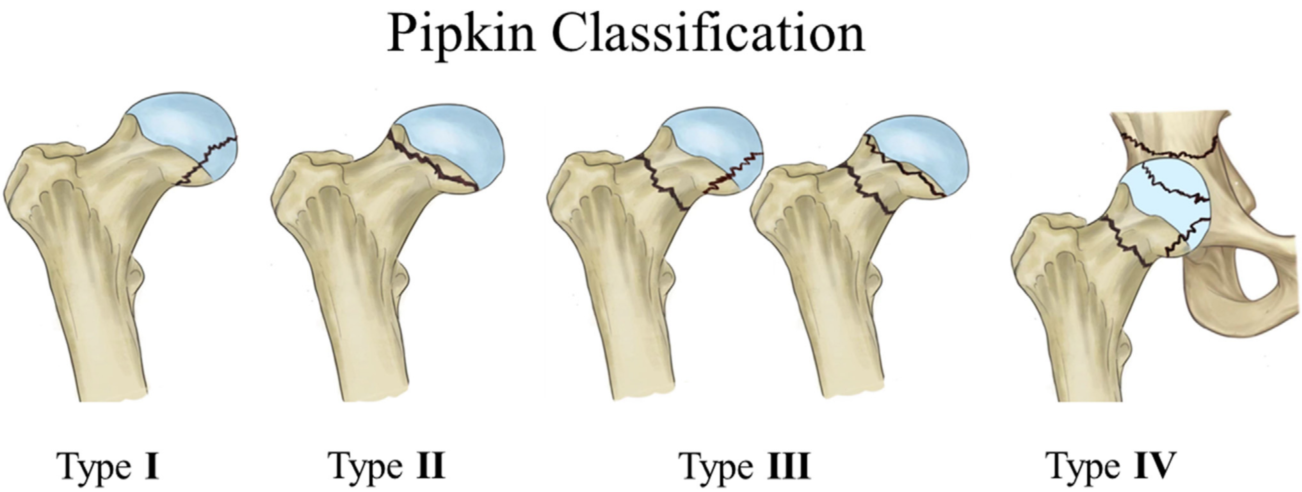

Fig 1. Pipkin classification. Type I: the fracture caudal to the fovea capitis. Type II: fracture cephalad to the fovea capitis. Type III: type I or II with a femoral neck fracture. Type IV: type I or II associated with acetabular fracture (right).

position on a hip arthroscopy distraction unit with the affected limb in maximal internal rotation and 5° to 10° hip flexion. The contralateral limb is secured in 45° abduction.

Skin Land Markers and Portals

The anterolateral, distal anterolateral, and mid-anterior portals are routinely established as observing and working portals. Depending on the need for posterior acetabular rim fractures and acetabular labral injuries, a posterolateral approach will be created. Care should be taken to avoid injury to the sciatic nerve with this approach.

Intra-articular Exploration and Debridement

A 30° arthroscope is placed through the anterolateral portal to reach the extracapsular space of the hip, and then instruments are introduced through the mid-anterior portal to expose the iliofemoral ligament and the anterior capsule. Longitudinal outside-in capsulotomy is performed with the technique we previously proposed.[8] A longitudinal capsular incision is made along the direction of iliofemoral ligament fiber parallel to the axis of femora neck, and the fluoroscopy would be helpful in guiding for capsulotomy if necessary. The incision is extended to the labrum proximally and femoral neck distally. Thereafter, a comprehensive arthroscopic exploration of the central and peripheral compartment of hip joint is performed to reveal the concomitant-free osteochondral fragments and ligamentum teres injury. All free osteochondral fragments are completely removed and the torn ligamentum teres are debrided with a 4.5-mm curved shaver (Smith & Nephew, Andover, MA) (Fig 3 A and B).

Fracture Reduction and Fixation

After the traction is released, the femoral head fracture is evaluated. The hip is kept by an assistant in a position of 45° of flexion, 30° of abduction, and 30° of external rotation, which facilitates visualization of the

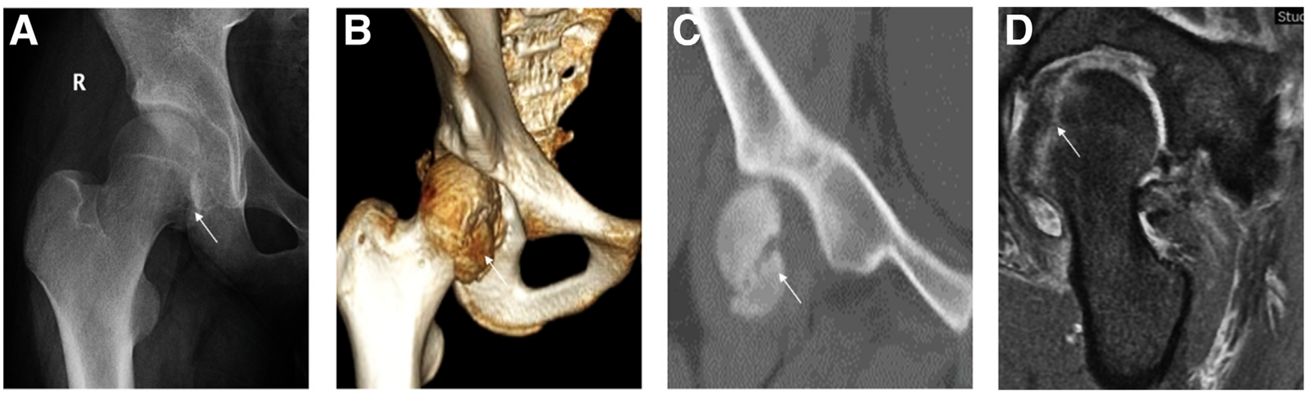

Fig 2. Typical case. Preoperative radiologic images of a 14-year-old male patient with right femoral head fracture (Pipkin type I) including radiography (A), computed tomography reconstruction (B and C), and magnetic resonance imaging (oblique sagittal proton density fat-suppression) (D), with white arrows indicating the facture line (right).

inferior medial fracture fragments. The displaced fracture fragments are well reduced with a probe through the distal anterolateral portal. Temporary fixation is performed with a 2.0-mm K-wire (Fig 3 C and D).

Double-Pulley Suture Technique

Two absorbable 3.0-mm anchors (DePuy Mitek, Raynham, MA) are tapped into bone bed, penetrating the fracture fragment, to form the medial row (Fig 3 E and F). One anchor is placed on the opposite side of the fracture line to form the lateral row (Fig 3G). One limb of suture from each medial anchor and one limb of suture from lateral anchor are retrieved from one portal and tied together, after that, the knot is pulled into the joint and another end of this paired suture was tied with a nonsliding knot, which formed a double-pulley fashion. The sutures on the surface of the femoral head eventually form the shape of the letter V (Fig 3H). The schematic diagram shows the anchors distribution and the suture knotting fashion of double pulley (Fig 4).

Closure of the Capsule

The stability of the fracture suture fixation is confirmed with the hip in full flexion and rotation. Finally, the joint capsule is closed with nonabsorbable sutures.

Postoperative Rehabilitation and Follow-Up

A hip brace is recommended immediately after surgery. Hip flexion is restricted to 30° to 60° for 2 weeks, 90° for 4 weeks, and 120° for 6 weeks. Partial weight-bearing with crutches is restricted for 6 weeks. Half squatting can be resumed 3 months after surgery. Competitive sports activities are prohibited for 6 months after surgery. Radiologic follow-up is performed 3 months after surgery (Fig 5).

Discussion

Femoral head fracture is a serious hip injury that requires surgical intervention in most cases. Conservative treatment is usually only indicated for nondisplaced fractures or fractures with displacement less than 2 mm. With the development of hip arthroscopy, arthroscopy-assisted metal screw fixation provides a new reliable method that is minimally invasive and has fewer complications. Park et al.[9] performed arthroscopy-assisted reduction and internal screw fixation in 3 patients with Pipkin Type I femoral head fracture and achieved satisfactory clinical results. Hip range of

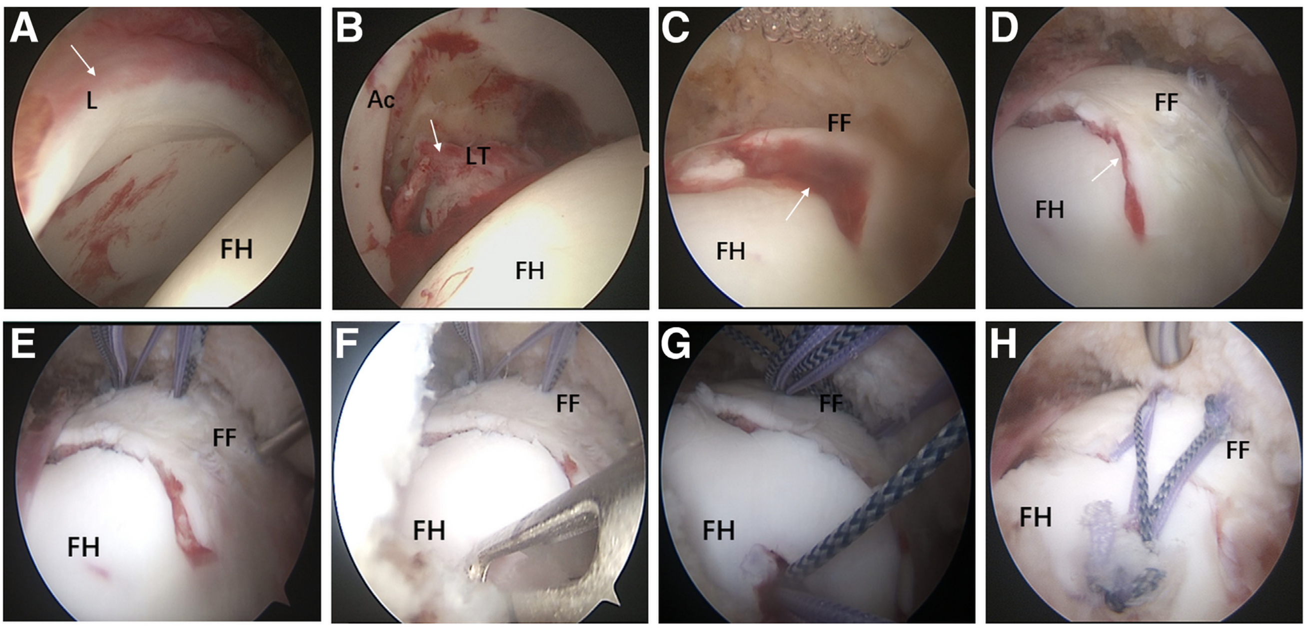

Fig 3. Arthroscopic views of the right hip from the anterolateral portal with a 30° scope showing the main procedures and intraoperative findings during arthroscopic management of femoral head fracture. (A) Arthroscopic view showing injury labrum (white arrow). (B) Arthroscopic view showing torn ligamentum teres (white arrow). (C) Arthroscopic view showing displacement of fracture (white arrow showing the fracture line). (D) Arthroscopic view showing the displaced fracture fragments are well reduced with a probe (VP: AL, OP: DALA). (E) Arthroscopic view showing 2 medial anchors implanted penetrating the bone fragment (VP: AL, OP: DALA). (F) Arthroscopic view showing the pre-drilling place of lateral anchor (VP: AL, OP: DALA). (G) Arthroscopic view showing the lateral anchor placed on the opposite side (VP: AL, OP: DALA). (H) Arthroscopic view showing suture bridge on the surface of femoral head formed the shape of letter V. (Ac, acetabulum; AL, anterolateral; DALA, distal anterolateral; FF, fracture fragment; FH, femoral head; L, labrum; LT, ligamentum teres; OP, operating portal; VP, viewing portal.) (right).

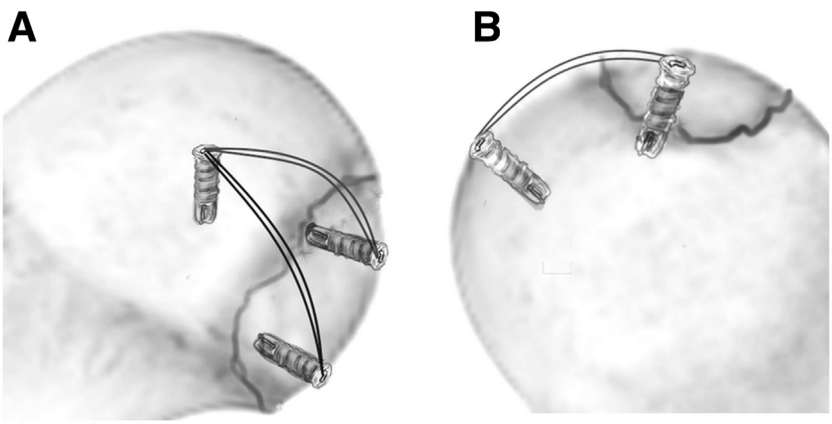

Fig 4. The schematic diagram showing the anchors distribution (A) and the suture knotting fashion of the double pulley (B) (right).

motion was fully recovered 3 months after surgery. Aprato et al.[10] compared postoperative imaging between arthroscopic internal fixation and open surgery for Pipkin type I fractures and found that the imaging results were similar, whereas the former had a better clinical outcome and a lower complication rate. Although metal screws can provide rigid fixation of fractures, they have limitations, including difficulty in arthroscopic manipulation and the risk of fragment disintegrating during screw insertion, especially for smaller and thinner fragments. It is also difficult to control the depth of screw insertion, and any displacement or breakage of the screw can lead to serious consequences.

Compared with fixation with metal screws, arthroscopic fixation with resorbable anchors for femoral head fractures offers several advantages. First, it avoids the need for any metal implantation and eliminates associated complications. Second, the use of smaller-diameter absorbable suture anchors reduces the risk of fracture fragment rupture. Third, in adolescent patients, the risk of epiphyseal injury is reduced. A limitation of this technique is that it is not indicated for cases with giant fragments or unreachable positions. There are several other limitations to this technique. First, it is not indicated for giant fragments that exceed the size of anchors. Second, it is difficult to expose the fragment located extremely laterally or medially by flexing hip. Meanwhile, the anchor fixation is not rigid but elastic. Table 1 details the pearls and pitfalls of our technique. Advantages and limitations of our technique are shown in Table 2.

The arthroscopic double-pulley technique was initially used to repair labral injuries and bony Bankart lesion of the shoulder.[11,12] We previously proposed a modified double-pulley technique for suture fixation of

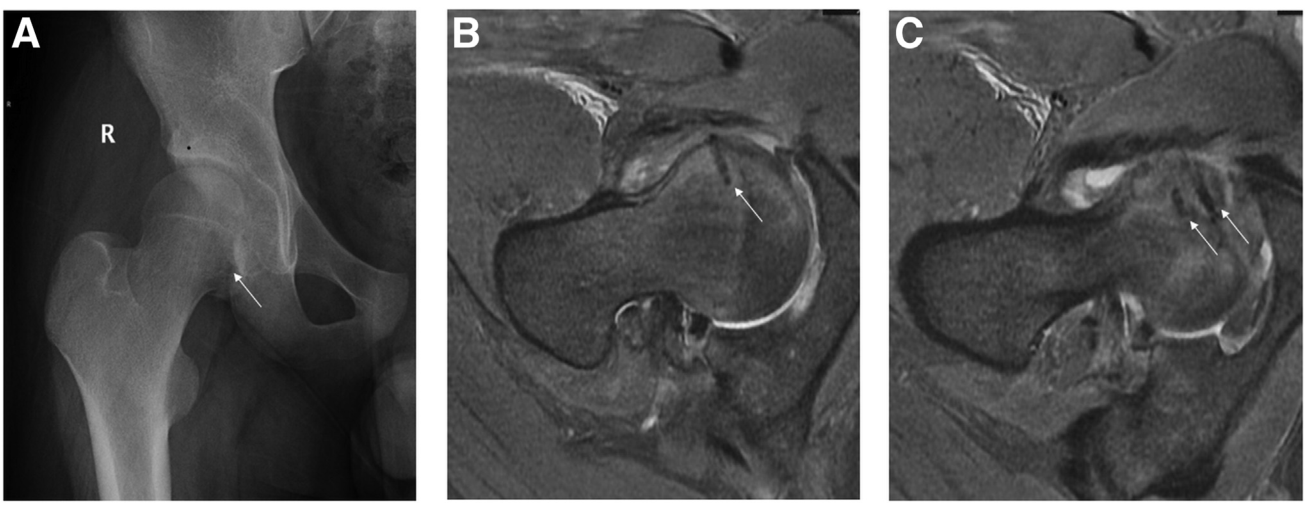

Fig 5. Postoperative radiologic images at 3-month follow-up. Pelvic radiography showing the fracture (white arrow) is reduced and well fixed (A); MRI (osag pd fs) showing the lateral row anchor (white arrow) (B); and MRI (osag pd fs) showing the medial-row anchors and healed fracture line (white arrow) (C). (MRI, magnetic resonance imaging; osag pd fs, oblique sagittal proton density fat-suppression.) (right).

Table 1. Technical Pearls and Pitfalls

Pearls	Pitfalls
Confirm the location and size of the fracture fragment of femoral head.	Femoral head fracture fragment is too small or too large.
Good reduction of fracture with probe and temporary fixation with K-wire.	Fracture fragment is totally displaced or difficult to reduce.
Small diameter anchor implant to avoid splintering the fragment.	Wrong angle when placing the anchor.
Predrill and place the anchor perpendicular to the surface of femoral head.	Sutures tangling when creating knots.
Make sure the anchor is tapped deep enough to be inserted into the bone bed.	

Table 2. Advantages and Disadvantages of the Technique

Advantages	Disadvantages
No metal screws are implanted, which avoids potential catastrophic complications.	Not suitable for fixation of large bone fragments.
Smaller-diameter anchor reduces the risk of splintering of fragments.	Not suitable for fixation of fragments located extremely medially or laterally
Fixation with absorbable anchor avoids secondary operation for implant removal.	The anchor fixation is not rigid but elastic.
More suitable for young patients with unclosed epiphysis.	Highly demanding arthroscopic technique.

acetabular os that resulted in favorable clinical outcomes.[13] In the present article, we have modified this technique for Pipkin type I femoral head fracture surgery. The method was designed with the following considerations for mechanical stabilization of the fragment: first, 2 anchors are tapped into the bone bed through the fracture fragment so that the tail of the anchors can hold the subchondral bone of the fracture fragment to form the initial fixation, and then the 2 anchors in the medial row and the lateral row anchor form a reinforcing fixation with downward pressure and reduce aggregation of the bone block through the double-pulley suture. The design of the 3 anchors forms a triangle with more stable mechanical properties. The acetabulum and surrounding labral tissue also provide compression and protection to the fracture fragments when traction is released and hip is flexed slightly.

This technique offers a reliable and simple new option for patients who have Pipkin type I fractures with fracture fragments located anterior to the femoral head. Fractures located posteriorly or extremely medially to the femoral head can be challenging.

Disclosures

All authors (X.-Y.Y., Y.L., W.-G.L., Q.-F.Y.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The study is supported by Science Foundation of The Second Hospital of Shandong University (2023JX15).

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