European Journal of Orthopaedic Surgery & Traumatology (2019) 29:1435–1439
https://doi.org/10.1007/s00590-019-02478-4

ORIGINAL ARTICLE • HIP - FRACTURES

Description of new "epsilon sign" and its significance in reduction in highly unstable variant of intertrochanteric fracture

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Received: 23 February 2019 / Accepted: 18 June 2019 / Published online: 24 June 2019

Abstract

Background Intertrochanteric fractures are commonly encountered in day-to-day trauma practice having various fracture patterns. Adequate reduction and appropriate fixation methodology is required for optimum results. However, failure rates are very high in unstable fractures. Here we describe a unique unstable variant of intertrochanteric fracture characterized by a long spike of proximal fragment, irreducibility of fracture with standard traction and internal rotation and soft tissue interposition. This appears as typical figure of 3 signs on right side and epsilon ε sign on left side on AP X-ray of pelvis with both hips.

Materials and methods In retrospective review of 924 intertrochanteric fractures treated at our institution from June 2005 to January 2017, twenty patients with this typical highly unstable fracture pattern (epsilon sign/figure of 3 at fracture site) were operated at our institution, which included 18 males and two females with average age of 43.5 years (range 30–60 years). All patients required open reduction with specific maneuver and dynamic hip screw fixation.

Results All patients had good reduction at the end of surgery, and all patients had good signs of clinico-radiological union at follow-up. None of the patients had implant loosening or screw back out.

Conclusion The typical radiological pattern seen on X-ray will guide the surgeon to predict this unstable variant of IT fracture preoperatively and will suggest toward requirement of open reduction with specific maneuver and internal fixation with dynamic hip screw.

Keywords DHS · Epsilon sign 'ε' · Reverse epsilon '3' · Intertrochanteric fracture

Introduction

Intertrochanteric (IT) fractures are one of the most common fractures seen in orthopedics practice [1, 2]. IT fractures are classified by various classification systems, most commonly used are Evan's classification and AO classification system [3]. These fractures are usually classified as stable or unstable depending upon the presence of posteromedial comminution, subtrochanteric extension, reverse obliquity and shattered lateral wall [4]. Closed reduction in the stable fractures is usually achieved by traction on fracture table in internal rotation. An unstable variety of IT fractures is reduced either in either internal rotation or external rotation depending upon the configuration of fracture pattern and may require additional maneuvers to co-apt the fracture fragments [5].

We observed a new radiological sign in a type of unstable IT fractures, which were very difficult to reduce closely and even on open reduction. This pattern of unstable fracture required extreme external rotation of distal fragment,

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Fig. 1 Antero-posterior X-ray of pelvis with both hips showing left intertrochanteric fracture and radiological sign of epsilon 'ε'

Fig. 2 Antero-posterior X-ray of pelvis with both hips showing right intertrochanteric fracture and radiological sign of reverse epsilon '3'

removal of interposed soft tissues (iliopsoas tendon and capsule), for reduction and fixation. In this study, we would like to describe a fracture pattern with typical radiological feature seen on plain radiograph on antero-posterior view as epsilon 'ε' on left side and reverse epsilon '3' on right side. This typical fracture pattern cannot be reduced by usual method of closed reduction and requires a different reduction maneuver and fixation.

Materials and methods

In this retrospective study, conducted from June 2005 to January 2017 at our institution, in a series of 924 IT fractures which were treated, 20 patients were observed typical radiological sign of '3' on the right side and epsilon 'ε' on left side (as shown in Figs. 1 and 2). The mean age of the patient was 43.5 years (range 30–60 years). There were 18 male patients and two female patients. These fractures were non-comminuted and had pertrochanteric extension, which was lateral to pyriform fossa with a long posterior spike of proximal fragment. A major portion of lesser trochanter (LT) being a part of proximal fragment and a small portion of LT was a part with the distal fragment with attached iliopsoas tendon. Proximal fragment was in external rotation with valgus displacement due to attachment of external rotators of the hip to the proximal fragment. We found out that the cause for irreducibility in these cases was the iliopsoas tendon which remains attached to the distal fragment of LT (as shown in Fig. 3).

Technique of fracture reduction

All patients were operated under spinal anesthesia in supine position on fracture table. C-arm images were obtained in orthogonal planes. In all cases, the proximal fragment was found widely separated from distal fragment, externally rotated and displaced anteriorly. Attempts at closed reduction were not possible by any maneuver of rotation necessitating open reduction in all the cases. All the cases were operated by lateral approach to expose the fracture site by splitting the fibers of vastus lateralis and detaching it from the vastus ridge. Exploration of the fracture site by finger palpation revealed soft tissue interposition between fracture fragments, making it impossible to close reduction. On further exploration and analysis and by retraction of anterior interposed soft tissue which consisted of iliopsoas tendon and capsule of hip joint, a Hohmann's spike was used to keep iliopsoas tendon out of the fracture surface. Special clamp was designed to hold the fracture in reduction (as shown in Figs. 4 and 5). This clamp is with unequal limbs and pointed ends (stan surgical-CNH clamp). Reduction was achieved by extreme external rotation of the limb along with holding the reduction with pointed clamps, holding the femur with Heygroove bone holding clamp and externally rotating the femur. Multiple guide wires were drilled across the fracture site out of the way of proposed DHS (dynamic hip screw) tract. Suitable DHS trajectory was selected with guide wire, and fixation was carried out with DHS screw and additional derotation screw (as shown in Fig. 6). On table compression required for fracture reduction in such a typical variant IT fracture was more than stable IT fractures, being this fractures remain distracted even after reduction. Limb was brought into neutral rotation after fixation and imaging was done in two planes to check TAD (tip apex distance) [6].

Results

Twenty patients were included in this study with this typical radiological sign of epsilon 'ε' on left side and reverse epsilon '3' on right side. Twelve patients had fracture on

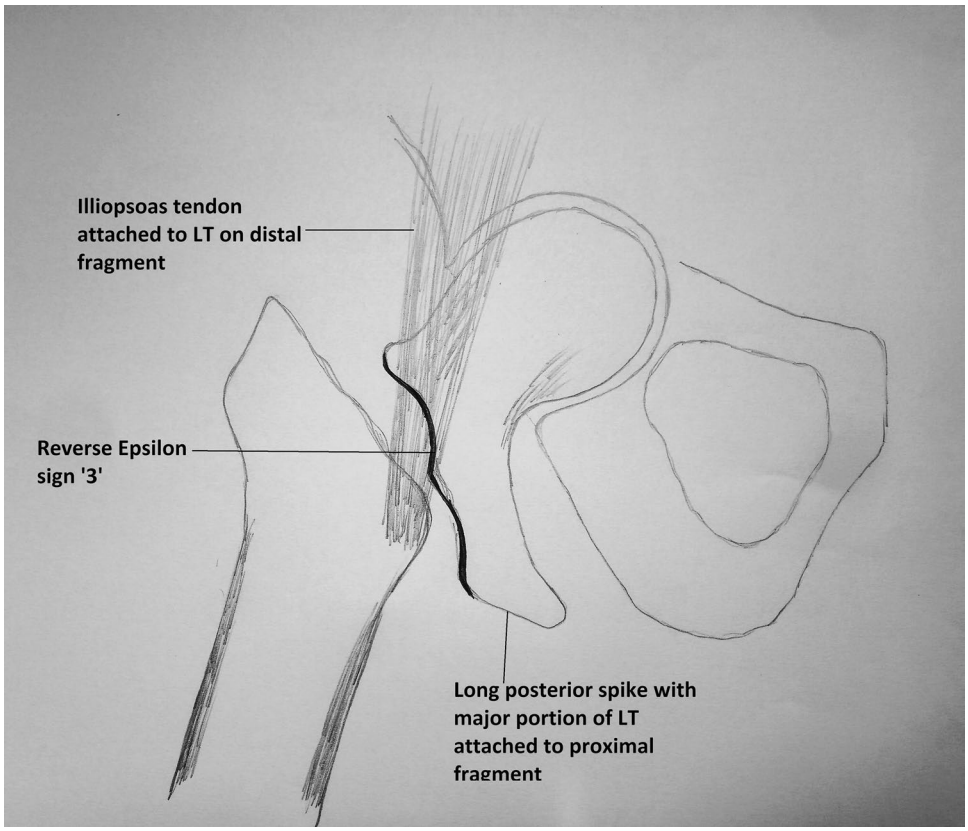

Fig. 3 Illustration of an unstable and irreducible variant of IT fracture on right side. The iliopsoas tendon remains attached to the lesser trochanter of the distal fragment, and the long spike on the head–neck fragment often gets caught between the iliopsoas and the lesser trochanter of distal fragment. Open reduction and extraction of interposed iliopsoas tendon is necessary to achieve a satisfactory reduction

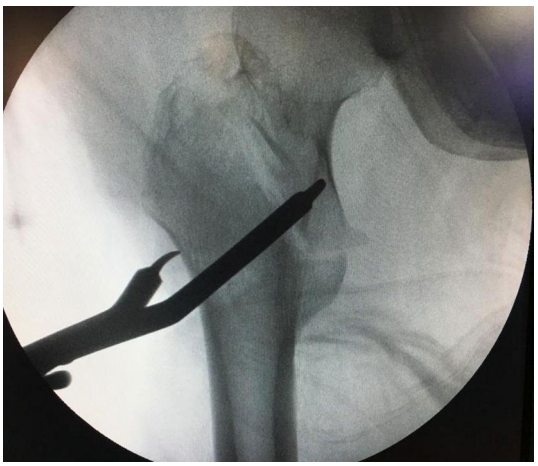

Fig. 4 Fluroscopy intraoperative image showing reduction in extreme external rotation and holding with special bone reduction clamp of unequal length

Fig. 5 Bone reduction clamp of unequal length

the left side, while eight patients had fracture on the right side. There were 18 males and two females with mean age of 43.5 years (range 30–60 years). Seventeen patients had fracture due to high velocity trauma, and three patients had fracture due to osteoporosis following trivial fall.

All patients were followed up at 6, 12, 24 weeks and 1 year. All patients had uneventful recovery with

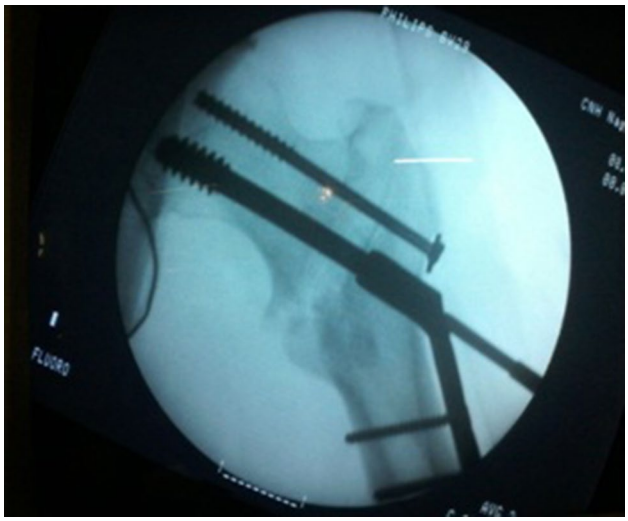

Fig. 6 Fixation with DHS

clinic-radiological signs of fracture reunion. None of the patients had implant loosening, screw back out or collapse at the fracture site.

Discussion

Intertrochanteric fractures (IT) typically extend from greater to lesser trochanter. The goal of surgical treatment is to achieve good reduction, stable fixation for early mobilization and fracture union. The IT fractures are typically reduced by axial traction with adduction and internal rotation [5]. In our series of 924 IT fractures, 20 patients were observed with atypical radiological epsilon 'ε' on left side and reverse epsilon '3' on right side. A variety of fractures were highly unstable and not amenable to reduction by routine method of reduction maneuver for IT fractures. This typical fracture pattern is a two-part fracture, with pertrochanteric extension and fracture line extending lateral to pyriform fossa with a long posterior spike and the lesser trochanter being mainly a part of proximal fragment. Proximal fragment was in external rotation and valgus displacement due to attachment of external rotators of the hip and gives the typical radiological appearance resembling alphanumeric 'ε'/'3'. We created similar fracture pattern on dried human bone and found that the proximal or upper limb of radiological 'ε'/'3' was made by bone overlapping along the posterior–superior margin of greater trochanter; the junction of upper and lower limb of 'ε'/'3' was around the bone overlapping in the digital fossa, and lower limb was made by the bone overlapping in the posterior crest and neck region.

Ottolenghin described pertrochanteric fractures based on pyriform fossa. He found that fractures lateral to pyriform fossa had external rotators attachment intact and those medial to it were lacking the same. Thus, he concluded that fractures with external rotators attachment intact to proximal fragment needed to be reduced in external rotation and these fractures were termed as "extradigital fractures" [7].

All 924 patients X-rays were reviewed and analyzed by authors individually to find out this typical unstable variant fracture pattern. Appearance of epsilon was found in external rotated X-rays of normal hips as noted in Fig. 1 on

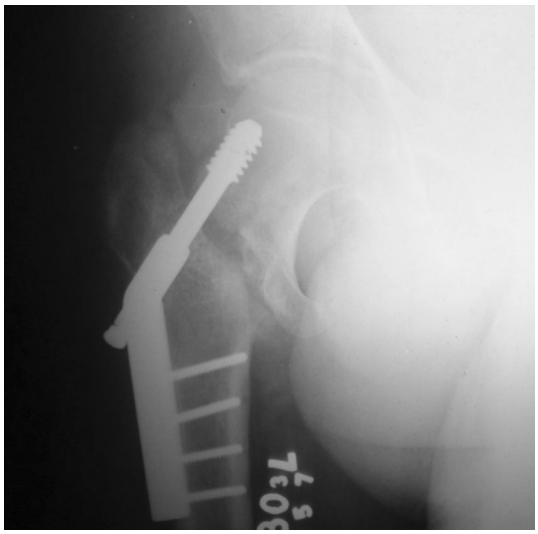

Fig. 7 Poor reduction and fixation as surgeon did not anticipate the typical fracture pattern which requires special reduction maneuver

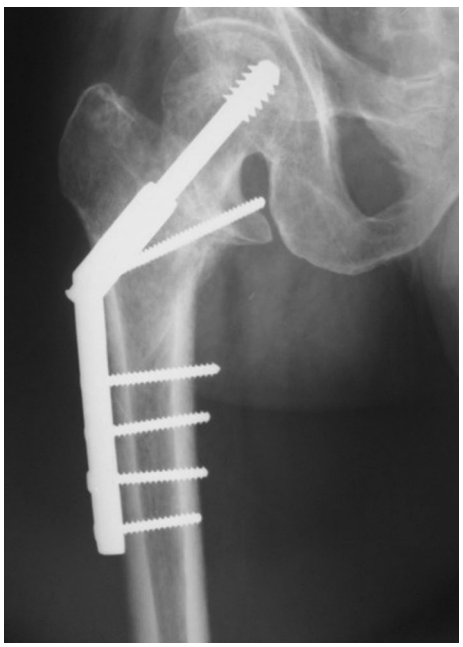

Fig. 8 Malunion as the surgeon did not anticipate the typical fracture pattern and hence poor fixation

normal side; however, the description of our new sign is at the fractured distal end of proximal fragment which helps to identify unstable variant quickly. On analysis of two cases (Figs. 7, 8), it will be realized that if this unstable fracture pattern is not properly analyzed it can result in suboptimal reduction and fixation and hence malunion at the fracture site.

Said et al. in their study also showed difficulty in closed reduction in fracture pattern in which lesser trochanter was mainly a part of proximal fragment and the iliopsoas tendon was interposed between the fracture fragments. The iliopsoas tendon is attached to the lesser trochanter of the distal fragment, and the inferior edge of the proximal fragments gets caught between the lesser trochanter of distal fragment and iliopsoas, making the reduction in the fracture impossible in internal rotation. The attachment of iliopsoas to distal shaft pulls the distal fragment proximally in front of the hip joint causing clinical swelling in front of the hip joint [8].

The typical radiological picture explained in this study will help the surgeon to anticipate this unstable fracture pattern by looking at antero-posterior X-ray and to plan open reduction and internal fixation for this fracture pattern following the typical reduction maneuver. Open reduction was achieved in all patients with this reduction technique in our study followed by fixation with dynamic hip screw and a derotation screw. All patients had clinic-radiological signs of union postoperatively, and none had implant loosening or screw back out.

In the literature, we identified an article by Said et al. which described the same finding, but the sample size was less in that study and reduction maneuver was not described in details. In our study, we have identified the pattern of such unstable fractures with epsilon sign in 20 cases among total sample size of control of 934 intertrochanteric fractures and described the maneuver in detail. We modified the reduction clamp for ease of reduction, and our experience is that it saves lot of time if the steps described in this paper are carried out. Also, we have identified the complications and described it if the fracture is not identified and reduced appropriately in such unstable intertrochanteric fractures.

Conclusion

The typical radiological appearance which resembles alphanumeric 'ε'/'3' on X-ray should guide the surgeon to predict this unstable variant of IT fracture, which requires open reduction, removal of soft tissue interposition and effective compression on table using dynamic hip screw.

Author's contribution RC—orthopedic surgeon, performed all the surgeries, NM—orthopedic surgeon, done the data collection and interpretation, AJ—orthopedic surgeon, done the data collection and interpretation, RA—orthopedic surgeon, done the data collection and interpretation, MS—orthopedic surgeon, done the data collection and interpretation and AK—orthopedic surgeon, done the data collection and interpretation.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The article does not contain any studies with human participants or animals performed by any authors.

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