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Role of Proximal Femoral Osteotomy in the Management of Developmental Dysplasia of Hip

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Abstract

Proximal femoral osteotomy as a component of the treatment of developmental dysplasia of hip (DDH) has been used for almost a century now, after being described by Hey-Groves in 1928. Over the years, understanding of its role has evolved alongside our improved knowledge on the pathoanatomy and biomechanics of DDH. It has come a long way from being used exclusively in older walking children; being used as the only other concomitant procedure with open reduction of hip and being used with pre-determined values to be achieved on table, to its present state of being an indispensable component of the a-la-carte approach of the treatment of DDH. A femoral osteotomy is used for shortening, decreasing the femoral anteversion, or for producing a varus at the proximal femur. The surgical technique has remained largely unchanged over the years although proximal femoral locking plates are now being increasingly used in addition to the traditional options such as angle blade plate, DCP, or one-third tubular plates. This review aims to analyze and summarize the current understanding of the role played by a proximal femoral osteotomy in the management of DDH.

Keywords: Developmental dysplasia of hip; Proximal femoral osteotomy; Varus derotation osteotomy; Avascular necrosis of femoral head.

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Introduction

Developmental dysplasia of hip (DDH) is a common pediatric condition requiring treatment. Ongoing research has contributed to a detailed understanding of its pathoanatomy and natural course which has in-turn enabled orthopedic surgeons to manage it better. The accepted treatment at present is of two major types - non-operative and operative. While non-operative treatment is the treatment of choice in children who are yet to start walking, operative treatment is often required for those who fail non-operative methods or who have already started to walk, where chances of a successful non-operative treatment are less [1].

From an embryological aspect, both the femur and the acetabulum develop from the same primitive mesenchymal cell with the two appearing as separate structures by around 11 weeks of intrauterine life [2]. In a neonate with normally developed hip joint, they are in close contact with each other from the surface tension created by the joint fluid. This surface tension resists dislocation of the femoral head from the acetabulum [2]. The structural changes in the femoral head and the acetabulum in childhood are dependent on the location of the femoral head in the acetabulum and the muscular forces acting on the proximal femur. Growth of the proximal femur results from a coordinated balance of growth at three main areas – upper femoral physeal plate, the greater trochanter, and the femoral neck isthmus [2]. The adductors, abductors, flexors, extensors, and rotators of the hip are the principal muscles acting on the proximal part of the femur. The femoral neck-shaft angle changes from around 150^{O} at birth to a value of around 135^{O} by adulthood [3]. Similarly, femoral neck anteversion changes from around 40^{O} at birth to 15^{O} at adulthood [4]. If the femoral head is well seated in the acetabulum and the muscular forces are balanced, these expected changes progress uneventfully and the final adult parameters are achieved. In addition, sphericity of the femoral head is maintained. If, however, the head is dislocated as in DDH, the proximal femur fails to develop appropriately. Sugano et al. [5] reported that adults with DDH having unreduced femoral heads tend to have femoral anteversion which is 10^{O} to 14^{O} greater than age- and sex-matched controls even though the neck-shaft angles between the two groups were not much different. Doudoulakis et al. [6] reported that increased femoral anteversion usually corrects spontaneously if the femoral head is well reduced in the acetabulum. A persistently dislocated hip might develop an eventual arthritis in adulthood [2]. Moreover, a normally developing femoral head is a stimulus for growth and development of the acetabulum, in the absence of which it might remain dysplastic. Thus, to promote normal growth and development of the hip joint, it is paramount that the dislocation is reduced well.

In children who are yet to start walking, treatment is aimed at achieving reduction by non-operative means [7]. In children who have started to walk but are younger than 18 months, attempts of closed reduction alone might fail; release of the foreshortened adductor longus is often necessary as an adjunct to closed reduction. In older children with DDH, who continue to walk with a dislocated hip, the femoral head is situated much higher than the acetabulum and the muscles attached around the proximal femur (iliopsoas and adductor group) are shortened [3]. This acts as an impediment to reduction.

In countries with well-established neonatal screening programs, early detection of DDH has become the norm over the past few years but there still are cases where the detection is delayed. In countries where the neonatal clinical screening practices are not uniform, the probability of a late detection is high. Orthopedic surgeons managing DDH patients must be well versed with concepts and techniques of both the non-operative and operative treatment. This review attempts to discuss the role of femoral osteotomy in the management of DDH.

Indications

Femoral osteotomy in DDH can be performed either as a stand-alone procedure or in combination with open reduction of the hip with or without an acetabular procedure. A proximal femoral osteotomy can be performed either at the inter-trochanteric or the sub-trochanteric level [8]. The common indications for performing a proximal femoral osteotomy are :

1. To facilitate reduction and to prevent proximal femoral growth disturbances: A femoral shortening osteotomy was primarily described for use in children older than 3-4 years of age [9]. However, it is increasingly being used in younger children too [11]. This shift in practice has enabled surgeons to avoid prolonged pre-operative traction, thus reducing the duration of hospitalization. The decision to perform a femoral shortening osteotomy can be made during open reduction of a dislocated hip. Once the obstacles to reduction of the hip are tackled, usually the femoral head can then be reduced into the acetabulum [12]. At this point, the muscular tension across the hip joint and its stability are assessed. In case, the surgeon needs excessive force to reduce the hip or the tension in the muscles around the hip is judged to be high or the hip tends to dislocate easily on axial loading at abduction of $<30^{O}$, a femoral shortening osteotomy should be performed [13].

In case, a tight reduction or a reduction in excessive abduction and flexion is accepted, there might be an increased pressure on the femoral head which is forced against the acetabulum and this might pre-dispose the head for avascular necrosis (AVN). Although AVN is the most commonly used term to indicate the growth retardation of the proximal part of the femur, Weinstein et al. have suggested to use the term proximal femoral growth disturbances (PFGD) instead of AVN [13]. They justify their stand based on unavailability of pathological confirmation of presence of necrotic bone in the femoral head. The high rates of AVN noted in studies which focused on treating all the dislocations by non-operative means [15] have now reduced to about 9-10% with the judicious use of femoral shortening osteotomy [11].

2. Addressing the proximal femoral anatomy: Anteversion of the femoral neck and the neck-shaft angle are two structural parameters which are affected by persistence of dislocation/subluxation of the hip. While the neck-shaft angle is not much different from normal in children with DDH, the infantile anteversion tends to persist [11]. Measurement of femoral anteversion can be done by clinical and radiological methods. Craig's test (Ryder method) is the clinical method for the estimation of femoral anteversion but is difficult to perform in a child. Determination by CT scan is the best method for accurate estimation of femoral anteversion [16]. However, it involves radiation exposure and the possible requirement of sedation in uncooperative children. Radiological determination performed before surgery in the operating room with the child under anesthesia is a practical method of anteversion estimation for surgical decision-making. In one such method, Sankar et al. [17] measured the offset from the center of the femoral head to the midline of the femoral shaft on anteroposterior and lateral views of the hip. The anteversion was then calculated using a simple trigonometric equation. Another method is to externally rotate the femoral shaft under fluoroscopy till the femoral shaft is aligned with the ossific nucleus of the femoral head. The amount of external rotation of the limb is estimated. Subtracting this value from 90^{O}gives the femoral anteversion value [12, 17].

While derotation was a routine component of femoral osteotomy in the past, the current advice is to individualize this decision [17]. This change was brought about by studies which have found that the femoral anteversion in children with DDH is not always abnormal [18]. Sankar et al. [17] found a wide variability in femoral anteversion (minimum 0^{O} and maximum 95^{O}). Thus, a fixed amount of derotation cannot be performed for all patients. Derotation should be done if the femoral anteversion is estimated to be more than 50^{O} or the reduction is judged to be stable only in internal rotation of more than 30^{O} on an intraoperative stability test [13, 17] (Fig. 1).

Previously, a proximal femoral varus derotation osteotomy (VDRO) was performed quite frequently as the only adjunct procedure to the open reduction of hip with the hypothesis that a deeply seated femoral head would stimulate the remodeling of the acetabulum [19]. However, it was not found to be superior to a concomitant acetabular procedure for promoting acetabular remodeling and as such is not routinely recommended at present [7, 11, 13, 17]. A decision to perform this is taken if the reduced hip is judged to be stable only in internal rotation and abduction during the intraoperative stability test (Fig. 2) [13]. It is favored by surgeons who consider that redirection of the femoral head toward the center of the acetabulum stimulates normal acetabular development [7].

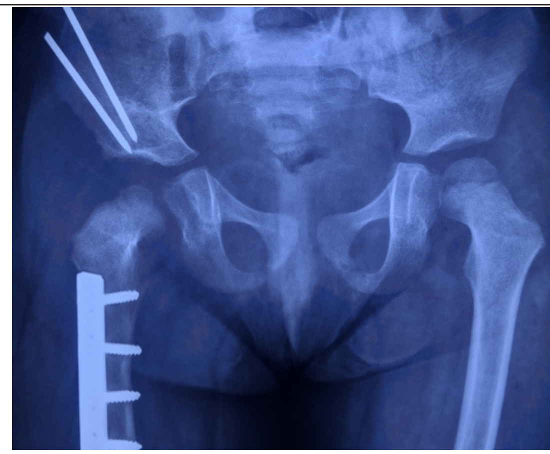

Figure 1: Antero-posterior radiograph obtained 6 months after surgery of a three and half years old girl for whom a femoral shortening and de-rotation osteotomy was combined with a Salter osteotomy and capsulorrhaphy.

Figure 2: Antero-posterior radiograph obtained 3 months after surgery of a 2 years old girl for whom a varus de-rotation osteotomy was performed at the time of open reduction.

Surgical Technique

The surgical technique of performing a proximal femoral osteotomy with or without derotation and varus has been well described [7, 8, 11]. It is performed in the supine position on a regular radiolucent operating table. Choice of implant depends on the location of osteotomy - an angle blade plate or a proximal femoral locking plate is preferred for an inter-trochanteric osteotomy; a 4-hole dynamic contact plate (DCP) or one-third tubular plate (single or stacked) can be used if the osteotomy is planned at the sub-trochanteric region [7, 8, 10]. The incision is made on the lateral aspect of the thigh extending from the tip of greater trochanter to as much distally as required. The vastus lateralis is incised from anterior to posterior at its attachment at the vastus lateralis ridge and then reflected anteriorly from the intermuscular septum taking care to identify and ligate the perforator vessels. Once the proximal shaft is exposed, a sharp thin osteotome or a saw blade is used to mark a longitudinal orientation line for judgment of the femoral rotation. If the plan is to perform a femoral shortening without derotation, then this line must be matched on either end after the shortening to ensure that no inadvertent rotation takes place. If the plan is to derotate, this line on either end of the osteotomy must make an angle equal to the desired derotation angle at the time of fixation. Another method of ensuring adequate derotation is to place two smooth Kirschner wires - one into the neck along its long axis and the other in the distal femur at an angle equal to the desired angle of derotation. Ensuring that these wires are parallel in the transverse plane at the time of fixation of results in achievement of the planned derotation [11]. If a DCP or one-third tubular plate is being used, pre-drilling the holes of the two proximal screws, inserting both the screws and removing one of them while loosening the other one and rotating the plate away before performing the osteotomy, makes it easier to apply the plate and hence stabilize the osteotomy site accurately [20].

The amount of shortening required varies from 1 cm to 3 cm. The recommended method to estimate the amount of shortening is by the overlap method (Sherman-Coleman overlap technique) [11, 21, 22]. After the first osteotomy cut, the femoral head is reduced into the acetabulum and the distal shaft segment is allowed to overlap over the proximal segment. The amount of overlap of the two segments with the hip reduced is the amount of bone which needs to be removed. A second cut parallel to the first one is made at the desired location and the osteotomy is stabilized with a plate [20]. During closure, the vastus lateralis must be sutured back at the vastus lateralis ridge [23].

Complications

Proximal femoral osteotomy as a component of DDH surgery does not usually produce complications if adequate pre-operative planning is done and a meticulous technique is followed. There is 9-10% chance of developing AVN (PFGD) and hence it becomes necessary that the patients are followed up well [14].

A major complication which may occur with a derotational osteotomy is an inadvertent posterior dislocation/subluxation of the hip (Fig. 3). This can happen if the femur is derotated excessively, and its possibility increases if a Salter innominate osteotomy and anterior capsulorrhaphy are performed too [13, 23]. The anterior capsulorrhaphy essentially consists of excision of redundant parts of superolateral and posterior capsule followed by suturing of the inferior capsular flap with the periosteum of the pubis [11]. This step imparts an internal rotation to the proximal femur [11, 23]. Femoral derotation internally rotates the femur too. In addition, a Salter innominate osteotomy redirects the entire acetabulum with an aim to improve the anterior and superior coverage of the acetabulum [23]. An iatrogenic posterior dislocation or subluxation must be addressed at the earliest. However, plain radiographs obtained in the post-operative period are usually inadequate for making a successful diagnosis. Axial CT scans of the hip are better in this regard and can be used to identify this complication [24]. The management in such a scenario would be to decrease the amount of

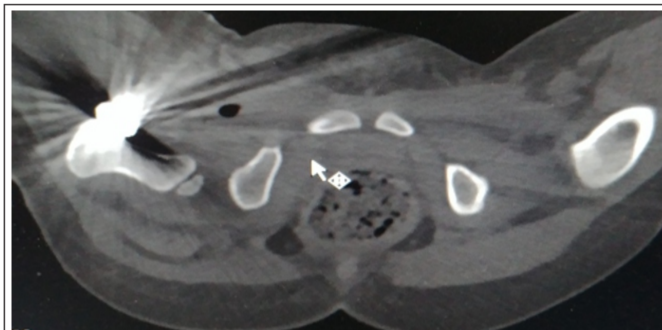

Figure 3: Axial CT scan image of the hip joint of a 3 years old child for whom capsulorrhaphy, and Salter osteotomy were done in addition to an overzealous femoral de-rotation. The right hip is dislocated posteriorly. This was revised by decreasing the amount of de-rotation.

femoral derotation. The hip should then be examined fluoroscopically on the operating table to ensure that the problem has been addressed successfully.

Eccentric ossification of the femoral head leading to a jockey-cap appearance after a derotation osteotomy was reported by Sangavi et al. [25] but none of the recent literature review discusses this finding. While no other specific major complication has been reported in the literature, other general complications associated with surgical procedures are possible. In addition, the plate used for fixation of the osteotomy needs to be removed in due course. If a VDRO was performed, correction of the femoral neck-shaft angle takes place over the next 3-4 years [25]. Temporary limp, limb length discrepancy, and some limitations in the hip range of motion are expected over this period. However, as described in the previous studies, the varus corrects overtime and the neck-shaft angle becomes comparable with that of the contralateral limb [25].

Conclusion

To summarize, proximal femoral osteotomy plays a central role in the successful management of DDH, especially in a walking child. This procedure not only saves the immature femoral head from PFGD (AVN) but by altering the proximal femoral anatomy promotes a more natural growth of the femur too. However, attention to detail is necessary and the surgery must be customized to the requirements of the patient.

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