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Review article

Patellar instability in children and adolescents

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ABSTRACT

Paediatric patellar instability encompasses many anatomic entities located along a continuum of knee extensor mechanism abnormalities. Major or minor clinical manifestations may occur at a variable age. In major forms with irreducible patellar dislocation or habitual patellar dislocation during knee flexion, shortness of the quadriceps is a consistent feature. A comprehensive aetiological work-up is in order, as syndromic conditions are common. Early surgical treatment is mandatory and should be performed by an experienced paediatric orthopaedic surgeon, as the procedure is technically challenging. Minor forms are more common; they are characterised by patellar dislocation or subluxation near terminal knee extension. The diagnosis may be difficult, particularly at the acute phase. Surgery is needed in patients with recurrent dislocation or functional impairments. The semiology of patellar instability has undergone considerable development in recent years, and a three-dimensional evaluation of patellar position can now be obtained using magnetic resonance imaging. Individually tailored surgical treatment "à la carte" remains a valid approach in 2013. However, new techniques for medial patello-femoral ligament reconstruction have modified the management strategies for adults and superseded many stabilisation procedures. Adapting these new techniques to paediatric patients and developing new procedures constitute major challenges.

1. Introduction

Patellar instability is a complex disorder of the knee extensor mechanism that was long poorly understood, as shown by the huge diversity of suggested treatments: over 100 different stabilisation procedures have been described for adults. The stakes are particularly high in paediatric patients, who exhibit the most severe forms requiring early management. In addition, patellar instability may occur in the setting of severe multiple or syndromic birth defects.

Recent detailed descriptions and biomechanical studies of the medial patello-femoral ligament (MPFL) constitute a major advance, as they have suggested new management strategies that have superseded many of the earlier procedures. The role for MPFL procedures in customised treatment strategies for paediatric patients remains undefined. These procedures cannot be viewed as a panacea. As with anterior cruciate ligament surgery in children, specific paediatric techniques have been developed for MPFL reconstruction, the optimal sequence, however, remains to be determined.

2. Specificities and novel procedures related to anatomic and biomechanical considerations

In 1995, Garin produced a detailed description of the embryological, anatomic, and biomechanical factors involved in patellar instability [1]. These factors will not be discussed here. Instead, we will review the new findings that may influence our management strategies.

2.1. Embryological studies

Embryological studies by Glard et al. indicate that the shape of the trochlear groove, a key feature of bipeds, is governed by genetic factors [2]. Trochlear biometrics is determined at the early foetal stages. Femoral torsion and the femoral neck-shaft angle, in contrast, develop under the influence of mechanical factors, which predominate over the genetic background. These studies support early management, as well as the inclusion of epiphyseal trochleoplasty into the surgical armamentarium.

2.2. MPFL

The MPFL is a well-defined anatomic structure that was identified recently. This ligament plays a crucial role as the main stabiliser of the patella between 0° and 30° of knee flexion. The MPFL is

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intimately mingled with the various layers of the medial retinaculum and contributes 50% to 80% of lateral patellar translation control [3]. MPFL rupture is a nearly consistent feature in patients with occasional patellar dislocation. The MPFL is not tubular; it resembles a triangular band with the base on the upper half of the patella and the tip on the femur. There is now general agreement that the femoral attachment of the MPFL in children is epiphyseal, a few millimetres distal to the growth plate [4,5]. The MPFL is not isometric: it is taut when the knee is fully extended and slack in flexion when the patella is engaged in the trochlear groove [6]. Many adult orthopaedic surgeons feel that the role for the MPFL is crucial [7]; however, in the more severe forms of patellar instability seen in paediatrics, the contribution of the MPFL remains to be determined.

2.3. Anterior distal femoral physis

The anterior distal femoral physis clearly marks the transition zone between the supra-trochlear femur and the cartilaginous trochlea. This important fact explains why metaphyseal elevation trochleoplasty involves only the supra-trochlear region and, by definition, remains outside the cartilage (with, in addition, a risk of migration during growth). Neither metaphyseal-epiphyseal elevation as described by Albee nor open-physis groove-deepening trochleoplasty should be performed, as these procedures produce a Salter–Harris type IV transphyseal lesion associated with a high risk of anterior epiphysiodesis and genu recurvatum.

3. Pathophysiology/factors responsible for instability

3.1. Major primary bone factors: dysplasia of the trochlea and patella

Dejour et al. showed that trochlear dysplasia is characterised radiographically by the crossing sign [8]:on the strict lateral view, the line along the trochlear floor intersects the anterior contours of the medial and lateral condyles. The crossing sign indicates a flat trochlea and is found in 96% of patients who have had at least one episode of true patellar dislocation (objective patellar instability) compared to only 3% of controls [8].

The crossing sign is not sufficient, however, to characterise a trochlea that is not only flat, but also convex. The supra-trochlear spur, or trochlear prominence, must be considered also, as well as the double contour formed by the projection of the hypoplastic medial side of the trochlea. These three radiological features are used to define the four types of trochlear dysplasia [8] (Fig. 1).

In children, trochlear ossification is incomplete, and the lack of ossification is greatest in the youngest patients, with the result that classification of the dysplasia may be impossible without a detailed analysis by magnetic resonance imaging (MRI) [9]. Furthermore, on axial views, the interpretation of trochlear remodelling requires great caution. An ultrasound study by Nietosvaara et al. documented changes in trochlear cartilage thickness between 12 and 18 years of age [10]. The cartilaginous trochlea of an abnormal knee is flatter than the bony trochlea, which makes the cartilaginous trochlear angle a better parameter for separating normal from abnormal knees. The positive correlation between the trochlear angle and patellar height when the knee is extended supports a role for developmental disorders, with decreased forces being applied to the trochlea in patients with patella alta.

The analysis of trochlear dysplasia cannot be separated from that of patellar dysplasia. A typology of patellar dysplasia is more difficult to develop, however, A pebble-shaped or hunter's-cap patella is often associated with the B and D types of trochlear dysplasia.

Other bone factors, which develop secondarily, may increase the risk of patellar instability. Examples include excessive anterior femoral torsion and genuvalgum. These factors change during growth.

3.2. A muscular factor: shortness and rotation of the quadricipital myotome and misalignment of the extensor mechanism

In quadricipital dysplasia, the muscle is abnormally short and rotated externally as a result of insufficient internal rotation of the

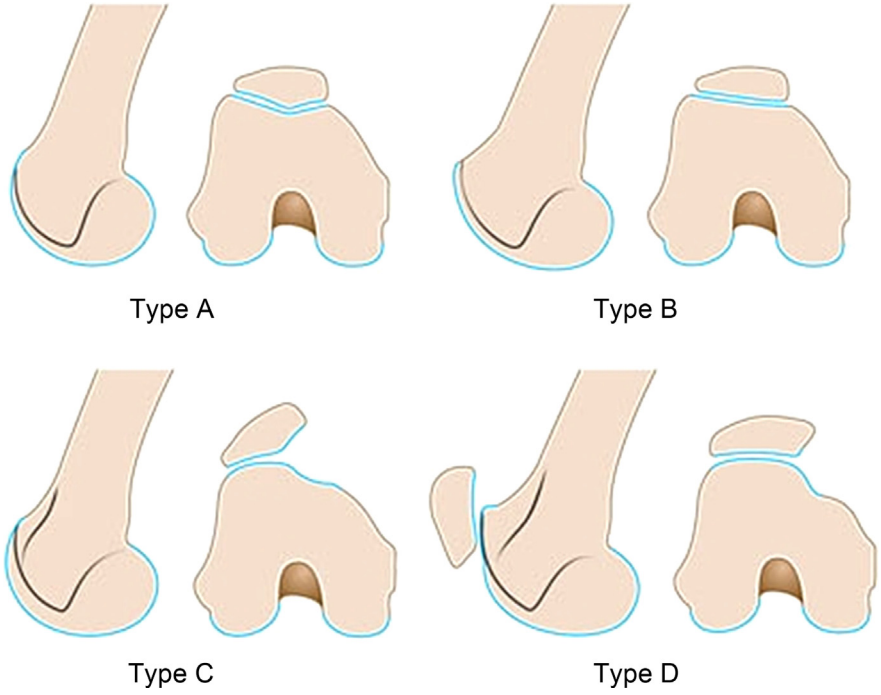

Fig. 1. Classification of trochlear dysplasia into four types according to Dejour [8]. Type A: crossing sign and shallow trochlea; type B: crossing sign, supra-trochlear spur, and flat trochlea; type C: crossing sign, double contour, and asymmetric trochlear slopes; type D: B + C, asymmetric trochlear slopes, and cliff pattern.