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TROCHLEAR DYSPLASIA – CONGENITAL ANOMALY OR BIOMECHANICAL DEVELOPMENT

TROHLEARNA DISPLAZIJA – KONGENITALNA ANOMALIJA ILI BIOMEHANIČKI RAZVOJ

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Summary

Introduction. The aim of this study was to investigate the appearance of the trochlear groove in infants and to present the possible causes for the development of trochlear dysplasia as one of the most severe pathologic findings in patients with patellar instability. **Material and Methods**. Knee ultrasonography was performed in 200 infants, 3 to 6 months of age. The measurements were made at 30 and 60 degrees of knee flexion, in order to measure the trochlear bone and cartilaginous sulcus angle on the patellar surface of the femur and to determine the degree of trochlear dysplasia. A 7-megahertz probe was used for measurements, which was tangentially placed with the reference to the posterior femoral joint. **Results.** A completely flat trochlear bony sulcus angle was registered in all infants aged 3 to 6 months. The mean cartilaginous sulcus angle was between 149 ± 5.4° and 19 infants had a sulcus angle over 159°. Eleven infants with trochlear dysplasia were in breech presentation at birth. **Conclusion**. Our study showed that the cartilaginous part of the trochlear groove was already well developed at birth. Breech presentation of the fetus could be a predisposing factor for dysplasia of the cartilaginous part of the trochlear groove. The bony part of the trochlear groove is dysplastic in infants and it gradually gets deeper, later getting a shape of the overlying articular cartilage. The influence of the Delpech law, with lower pressure in the trochlear groove, could be the possible mechanical theory explaining the development of the trochlear dysplasia in the later stage of the childhood.

Key words: Joint Instability; Patellofemoral Joint; Ultrasonography; Infant, Newborn; Infant; Breech Presentation; Risk Factors; Models, Theoretical

Sažetak

Uvod. Cilj ove prezentacije je da pokaže pojavu trohlearnog žleba kod novorođenčadi i da predstavi mogući uzrok razvoja trohlearne displazije kao jednog od najtežih patoloških nalaza kod pacijenata sa nestabilnošću patele. **Materijal i metode.** Ultrasonografija je obavljena na 200 novorođenčadi uzrasta od tri i šest meseci. Merenja su izvedena u fleksiji kolena od 30 i 60 stepeni, kako bi se izmerili trohlearni koštani žleb i ugao na hrskavičavoj površini čašice i kako bi se odredio stepen trohlearne displazije. Pre merenja korišćena je 7 MHz linearna sonda koja je postavljena tangencijalno u odnosu na patelofemoralni zglob. **Rezultati.** Kod svakog novorođenčeta uzrasta od tri i šest meseci registrovan je potpuno ravan trohlearni koštani žleb. Prosečan ugao hrskavičavog sulkusa bio je između 149±5,4° a 19 novorođenčadi imalo je ugao sulkusa više od 159°, dok je 11 sa trohlearnom displazijom imalo karlični položaj pri rođenju. **Zaključak.** Naša studija pokazala je da je hrskavični deo trohlearnog žleba već dobro razvijen na rođenju. Karlična prezentacija fetusa može biti predisponujući faktor za displaziju hrskavičnog dela trohlearnog žleba. Koštani deo trohlearnog žleba je displastičan kod novorođenčadi i postepeno dobija dubinu kako bi preuzeo oblik zglobnog hrskavice. Uticaj Delpešovog zakona objašnjen je smanjenim pritiskom u troholarnom žlebu, te je moguće mehaničkom teorijom objasniti razvoj trohlearne displazije u kasnijoj fazi detinjstva.

Ključne reči: nestabilnost zgloba; patelofemoralni zglob; ultrasonografija; novorođenče; odojče; karlični porođaj; faktori rizika; teoretski modeli

Introduction

Patellar instability is a complex orthopedic problem, especially due to the multifactorial etiology. The anatomy of the femoral trochlea is of vital importance for the stability of the patellofemoral joint. Knowing the characteristics of the femoral trochlea in newborns may prove useful when considering the predisposing factors for patellar instability. The dysplastic trochlea was first discovered and described by Richerand in 1802, and its surgical correction performed by elevation of the lateral femoral condyle was described by Albe in 1915 [1]. Brattstorm and Maldague [2, 3] gave the first classification of trochlear dysplasia using axial X-rays of the knee and Dejour H. et al. [4–8] gave the second classification based on the level of the trochlear line crossing with the lines of the two condyles, seen on profile X-rays. According to the studies, there is no consensus about the etiology of the trochlear dysplasia. There is no consensus whether it is genetic in origin [9], caused by imbalanced forces indicating maltracking and re-

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Abbreviations
CT – computerized tomography
MRI – magnetic resonance imaging
SA – sulcus angle

modeling of the trochlea during infancy and growth [10], or due to other unknown factors. Results of some recent studies [11, 12] indicate that dysplasia of the femoral trochlea may be congenital, with a breech presentation of the fetus as a major risk factor for its development. It is likely that excessive lateral pressure during growth and development will modify the shape of the patella as well as the trochlea. This would follow the law of Delpech [9] enunciated in 1829, concerning the influence of compression and tensile forces on an epiphysis. This indicates that dysplasia of the femoral trochlea can also be caused by development.

Axial radiographs do not show cartilaginous structures and therefore give little information about the trochlea shape and patelofemoral articulation in infants and small children [13–15]. Contrast methods are invasive and cumbersome, while computerized tomography (CT) and magnetic resonance imaging (MRI) in small children necessitate sedation or anesthesia. As a method of visualizing the newborn femoral trochlea and the position of the patella, ultrasonography is a reliable tool to define the configuration both the osseous and cartilaginous femoral sulcus. The sulcus angle (SA) is the closed angle defined by the intersection of the lines parallel to the articular cartilage of the medial and lateral femoral facets. It is easy to measure and interpret, so it is commonly used to describe dysplasia of the femoral trochlea. The SA was found to be the most reliable parameter, with an intra-examiner variation of −1°, standard deviation (SD) 2.5 and an inter-examiner variation of 0° (SD 2.1) [11].

The purpose of our study was to investigate the appearance of the trochlear groove in infants using ultrasonography and examine the possible causes for the development of trochlear dysplasia.

Material and Methods

A right knee ultrasonography was performed in 200 infants (120 male and 80 female) aged 3 to 6 months. The measurements were performed at the University Clinic for Orthopedic Surgery in Skopje, with knee flexion at 30 and 60 degrees, in order to measure the bony and cartilaginous SA on the patellar surface of the femur **(Figure 1)**. The measurements were performed using a 7 MHz linear-array probe, which was tangentially placed with the reference to the posterior femoral joint **(Figures 2 and 3).** The osseous and cartilaginous SAs were measured at the level of the most ventral point on the lateral patellar facet of the femur. We took SA of over 159 degrees to indicate trochlear dysplasia.

All data were expressed as mean ± SD and analyzed by statistical package for the social sciences (SPSS) 12.0 software. Group comparison was performed with the Student t-test and $p < 0.05$ was considered statistically significant.

Figure 1. Knee ultrasound examination of a 3-month newborn; the probe is in a perpendicular position to the knee joint
Slika 1. *Ultrazvučni pregled kolena kod tri meseca starog novorođenčeta. Sonda je pod pravim uglom postavljena na koleno za vreme pregleda*

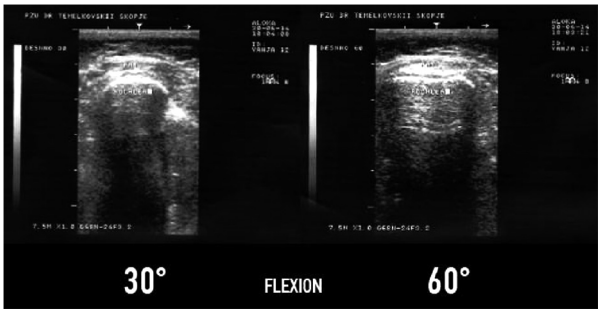

Figure 2. Ultrasonographs of a 3-month infant; the trochlea is flat at 30 and 60 degrees of flexion
Slika 2. *Ultrazvučni pregled tri meseca starog novorođenčeta. Trohlerana površina pod uglom 30 i 60 stepeni savijanja kolena*

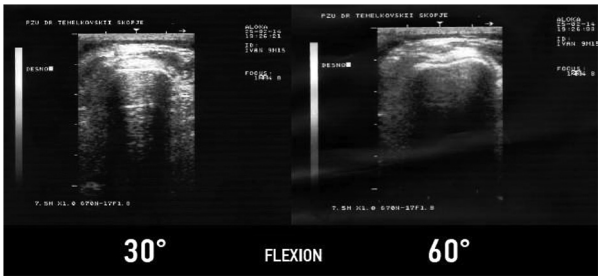

Figure 3. Ultrasonographs of a 6-month infant; the trochlea is still flat at the same degrees of flexion
Slika 3. *Ultrazvučni pregled šest meseci starog novorođenčeta. Trohlerana površina pod istim uglom savijanja kolena*

Results

A completely flat bony SA was registered in all infants. The mean cartilaginous SA was 149 ± 5.4° and 19 infants had a SA over 159°. Eleven infants with trochlear dysplasia were in breech presentation at birth **(Table 1)**. Moreover, we did not observe significant difference in the femoral cartilaginous SA with

Table 1. Presentation of the mean trochlear sulcus angle, number of infants with trochlear dysplasia and number of infants born in breech position with gender distribution
Tabela 1. *Prosečene vrednosti trohleranog ugla, broj dece sa trohleranom displazijom i broj dece rođene karličnim položajem u odnosu na pol*

	Female/*Ženski*	Male/*Muški*	All/*Svi*
Mean ± SD/*Prosek ± SD*	148 ± 6.4	150 ± 5.4	149 ± 5.4
Dysplastic/Normal (%)/*Displastičan/Normalan*	11/120 (9.2%)	8/80 (10%)	20/200 (9.5%)
Presentation/Dysplastic (%)/*Prezentacija ploda/Displastična trohlea*	6/11 (54.5%)	5/8 (62.5%)	11/20 (55%)

respect to various degrees of knee flexion during the measurements.

Discussion

An abnormally shallow trochlear sulcus has been reported to be an important factor in patellar instability [16, 17]. Trochlear dysplasia means that the trochlea is flat or dome shaped and there is no congruence between the patellar and trochlear facets. Dysplasia of the lateral femoral condyle is particularly important, because of the bony support that prevents lateral patellar dislocation. Although cartilage of the patellofemoral joint is visualized in CT scans and MRI, both methods provide images of the centre of the patellar articular cartilage [18]. This makes it difficult to compare measurements of the femoral sulcus, because the vertical position of the patella varies between individuals. The ultrasonographic technique allows the measurement of both osseous and cartilaginous trochlear sulci at a constant and reproducible point of reference, the most of the anterior part of the lateral patellar facet of the femur. Our study showed that cartilaginous trochlear sulcus is well developed at birth. The mean value for the cartilaginous SA in our study correlates with the results presented in other recent studies. Results of our study showed that dysplasia of the femoral trochlea can be also congenital, with a breech presentation of the fetus as a major risk factor for its development. We found about 10% newborns with trochlear dysplasia and more than half of them were in breech presentation at birth. That means that the shape of the fetal femoral trochlea appears to be susceptible to the influence of mechanical forces. A moving knee with normal patellar tracking in the final stage of pregnancy may be of vital importance for normal anatomy [12]. A fetus with space to kick and flex the lower limbs has a good prospect of developing a femoral trochlea with the depth needed to support the patella. There are also studies which show that the anatomic characteristics of the trochlea could be integrated into the genome during the course of evolution. This would be in favor of the genetic origin of trochlear dysplasia [19]. We found flat bony trochlear sulcus in all infants, which means that it gets deeper during growth, getting a shape of the overlying articular cartilage probably by the adolescence.

The basic postulate for biomechanical development of the dysplastic trochlea is the Delpech law, according to which the cartilage of diarthrodial joints transfers decreased pressure and the neighbouring growth cartilage is in reverse proportional hyperactivity. In the human newborn and non-walking children the femoral diaphysis is vertical. As the child starts walking, the femoral obliquity angle develops between 1 and 7 years of age, inducing a secondary valgus of the extensor apparatus, physiological patellofemoral pressure and modifications of the patellofemoral joint. That correlates with the results from the recent experimental studies on animals where patellar malpositioning caused by patellar tendon Z-plasty lengthening or medial patellar soft tissue restraints release leads to more flattened trochlea and predisposition for patellar instability.

Conclusion

Our study showed that the cartilaginous part of the trochlear groove is already well developed at birth. Dysplasia of the femoral trochlea may be congenital, with a breech presentation of the fetus as a major risk factor for its development. Bony part of the trochlear groove is dysplastic in newborns and it gradually gets deeper, in time getting the shape of the overlying articular cartilage. According to the Delpech law, the development of the trochlear dysplasia in the later stage of childhood may be explained by lower pressure in the trochlear groove, in favor of the mechanical theory.

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