ACTA
ORTHOPAEDICA
et
TRAUMATOLOGICA
TURCICA

Acta Orthop Traumatol Turc 2010;44(3):229-234
doi:10.3944/AOTT.2010.2236

The morphological features of the mediopatellar and lateral folds of the developing knee joint: a fetus cadaveric study

Zeliha KURTOĞLU, Deniz UZMANSEL, Mustafa AKTEKİN

Department of Anatomy, Medicine Faculty of Mersin University, Mersin

Objectives: The aim of the study was to evaluate the morphological features of the mediopatellar and lateral folds in fetal knees in the absence of any exposure to certain stress factors such as exercise or trauma.

Methods: The study was performed in the knee joints of 15 fetuses (6 males, 9 females) obtained as spontaneous abortion material at 20-34 weeks of gestation. The mediopatellar and lateral folds of the fetuses were classified into eight subgroups according to the following morphological features: A- Absence of folds; B- Short vertical band; C- Long vertical band; D- Narrow horizontal band; E- Broad horizontal band; F- Horizontal band accompanied by a vertical band; G- Horizontal band without a vertical band; H- Fenestrated band.

Results: The synovial membrane, covering the infrapatellar fat pad and forming the alar folds, extended upwards and formed the medial and lateral horizontal folds that covered the inferior part of the posterior aspect of the patella. These horizontal folds were thicker in the lower parts (close to their insertions) and became thinner towards the free ends. The horizontal band of the mediopatellar fold was observed in all cases, with an accompanying vertical band in 76.7% of the cases. A horizontally located lateral fold was absent in both knees of one fetus. The frequency of a horizontally located lateral fold was 93.3% and a vertical fold was accompanying in only 28.6% of these cases. It is of note that the horizontal band of the mediopatellar fold observed in all specimens has never been defined in previous classifications. In 10% of the knees, the vertically located part of the mediopatellar fold presented as a large band extending upward and being squeezed between the articular surface of the patella and the medial condyle of the femur. The lateral fold was observed as a large band in 10% of the knees. Another observation was that the higher level the vertical band of the mediopatellar and lateral folds began, the wider the horizontal band was, occupying more place in the patellofemoral space. It was remarkable that the frequencies of the vertically located parts of the lateral and mediopatellar folds in fetuses were higher than those reported for the adults in the literature.

Conclusion: Our findings suggest that the resorption process of the mesenchymal tissue, particularly in the lateral part, continues until adulthood and causes age-dependent alterations in the formation of intra-articular folds. The synovial folds occupy more space between the patella and femur in the early stages of life than seen in adults. This may be a more frequent cause of unexplained knee pain in children than expected.

Key words: Cadaver; knee joint/embryology/anatomy & histology; patella/anatomy & histology; synovial membrane/embryology/pathology.

This study received support from the Unit of Scientific Research Projects of Mersin University (No: BAP TF TTB(ZK)2004-3).

Correspondence: Zeliha Kurtoğlu, MD. Mersin Üniversitesi Tıp Fakültesi, Anatomi Anabilim Dalı, 33169 Mersin, Turkey.
Tel: +90 324 - 341 08 78 e-mail: zkurtoglu@mersin.edu.tr

Submitted: March 10, 2009 **Accepted:** September 14, 2009

Joint cavity formation begins in the eighth week of gestation. Multiple small cavitations around the femoral condyle and patella unite to form a single cavity until the 10th week.[1] The mesenchymal tissue remnants medial to the patellofemoral joint constitute the mediopatellar fold (MF) while those lateral to it form the lateral fold (LF). The synovial membrane that lines the infrapatellar fat pad (Hoffa fat pad) (IPFP) extends backward between the tibial and femoral condyles, forming the alar folds.[2,3]

Awareness of the variations in the morphological features of intra-articular synovial folds is crucial during arthroscopy. Moreover, some of the subgroups of these folds may cause susceptibility to plica syndrome.[1,4-6] Some of these folds in the adult knee joint have been classified by several authors.[4-8] However, there is not sufficient data in the literature regarding the morphological features of these folds in fetuses. We suggest that the resorption of the MF and LF might continue even in the early periods of life (in infancy, childhood, and perhaps adolescence) and these folds might reach their adult dimensions after these periods. Thus, the MF and LF might occupy more space within the knee joint in the early periods of life compared to that seen in adults. It has also been demonstrated that some types of these folds may undergo morphological changes due to trauma and exercise during adulthood.[9-12]

We aimed to determine the morphological characteristics of these folds in fetuses and to compare them to those of adults reported in the literature. We also investigated the frequency of the subtypes with large folds that might be associated with knee pain in the early period of life.

Materials and methods

This study was carried out in the knees of 15 fetuses (6 males, 9 females) at 20-34 weeks of gestation. All fetuses were of spontaneous abortion material that had been submitted to the Pathology Laboratory of Medicine Faculty of Mersin University for autopsy studies between 2000 and 2007. All dissections were made with a surgical microscope (Leica M-651) in the Anatomy Department of Medicine Faculty of Mersin University. After the removal of the skin over the knee, a U-shaped incision was performed starting at the medial aspect of the medial epicondyle of the femur, passing the upper part of the tibial tuberosity, and extending to the lateral aspect of the lateral epicondyle. The medial and lateral patellar retinacula were carefully released. Then, the patellar ligament and infrapatellar fold were dissected and the patella was pulled upwards. The folds on both sides of the posterior aspect of the patella were examined and photographed. The mediopatellar and lateral folds were classified in eight subgroups as follows (Table 1, Fig. 1, 2):

A- Absence of folds.

B- Short vertical band: vertically located synovial fold beginning inferior to the upper border of the patella (Fig. 1).

C- Long vertical band: vertically located synovial fold beginning superior to the upper border of the patella on the medial or lateral wall of the patellofemoral joint (Fig. 1, 2a).

D- Narrow horizontal band: horizontally located synovial fold covering only the inferior border of the posterior surface of the patella (Fig. 1, 2b).

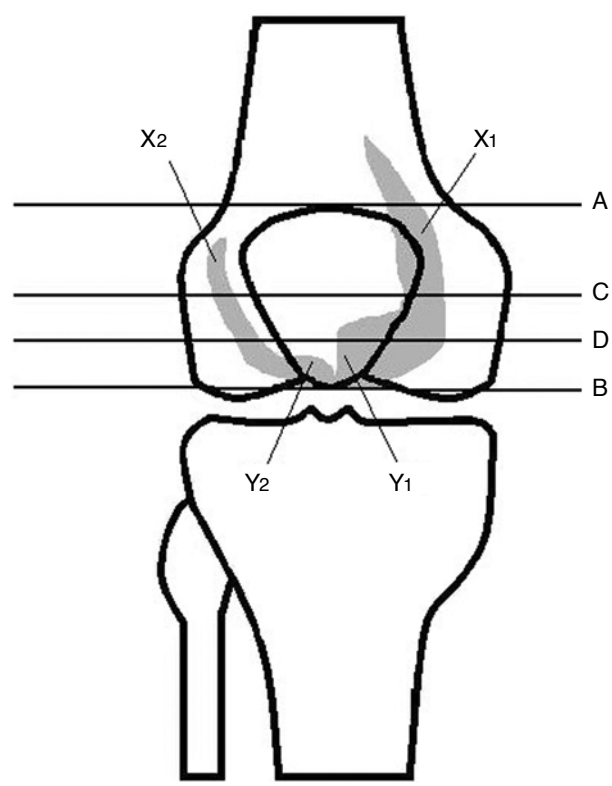

Fig. 1. The reference lines used for the classification of the mediopatellar and lateral folds. A: The upper border of the patella; B: The lower border of the patella; C: The midline of the patella; D: The midline of the distance between the lines B and C; X1: Long vertical band; X2: Short vertical band; Y1: Broad horizontal band; Y2: Narrow horizontal band.

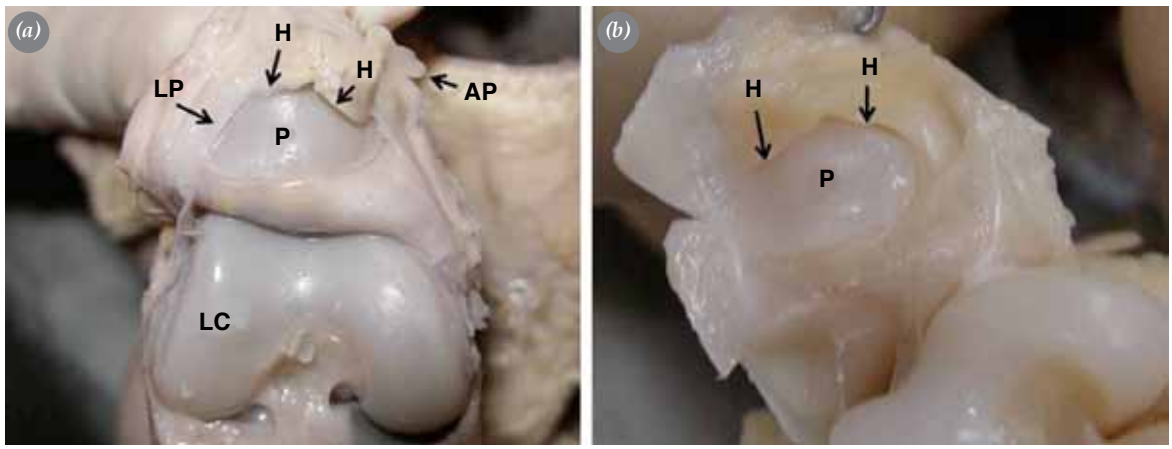

Fig. 2. Appearance of the right knee joint with the patella retracted upward. **(a)** A long vertical band of the lateral fold (LF) and a short vertical band of the mediopatellar fold (MF) accompanied by a broad horizontal band. **(b)** The MF and LF formed by only a horizontal band without any vertical band. H: Horizontal band; AF: Alar fold; P: Patella; LC: Lateral condyle of the femur.

E- Broad horizontal band: horizontally located synovial fold covering the inferior half of the medial or lateral part of the posterior surface of the patella (Fig. 1, 2a).

F- Horizontal band accompanied by a vertical band: Horizontal fold with an accompanying vertical fold as in B or C (Fig. 2a).

G- Horizontal band without a vertical band (Fig. 2b).

H- Fenestrated band: fold as seen in B or C with hole(s) on it.

Results

The synovial membrane, covering the IPFP and forming the alar folds, extended upwards and formed the medial and lateral horizontal folds that covered the inferior part of the posterior aspect of the patella. These horizontal folds were thicker in the lower parts (close to their insertions) and became thinner towards the free ends.

The frequencies of the subgroups of the mediopatellar and lateral folds are presented in Table 1. The horizontal portion of the MF was observed in all cases and a vertical fold was accompanying in 76.7% of the cases. A horizontally located LF was absent in both knees of a case. The frequency of a horizontally located LF was 93.3% and a vertical fold was accompanying in only 28.6% of these cases (Table 1).

Table 1

Frequencies of subtypes of the mediopatellar and lateral folds

	Mediopatellar fold					Lateral fold				
	Right	Left	Total	%	Total %	Right	Left	Total	%	Total %
Absent	0	0	0	0		1	1	2	6.7	
Short vertical band	9	11	20	66.7	76.7[+]	3	0	3	10.0	26.7[+]
Long vertical band	2	1	3	10.0		3	2	5	16.7	
Narrow horizontal band	3	2	5	16.7	100[++]	5	8	13	43.3	93.3[++]
Broad horizontal band	12	13	25	83.3		9	6	15	50.0	
Horizontal band with vertical band	11	12	23	76.7		6	2	8	28.6[*]	
Horizontal band without vertical band	4	3	7	23.3		8	12	20	71.4[*]	
Fenestrated band	0	0	0	0		0	0	0	0	

[+]Total percentage of the cases with a vertical band; [++]Total percentage of the cases with a horizontal band; [*]Percentage among the cases with a horizontal band.

Between the medial/lateral horizontal bands and the patella, a pouch formation of varying depth was observed. When a vertical band of the MF or LF existed, this was observed as the continuation of the horizontal part. The pouches of the horizontal plicae accompanied by a vertical band were deeper than those without a vertical band.

Another observation was that the higher level the vertical band of the MF or LF began, the wider the horizontal band was, occupying more place in the patellofemoral space.

The connection point of the medial and lateral horizontal bands was always the point where the infrapatellar fold was attached to the IPFP.

Vertical parts of the MF in three cases and of the LF in four cases presented as the continuation of the suprapatellar fold.

Discussion

The mediopatellar fold, which is located close to the medial femoral condyle, is also known as shelf plica, plica synovialis mediopatellaris, medial synovial shelf, Iino band, Aoki shelf, meniscus of the patella, plica alaris elonga, or medial intra-articular band.[2-6,8] Its frequency in adults has been reported as 39-47%.[1,6,7] The frequency of the LF which is located close to the lateral femoral condyle has been reported as 1-3%.[1,13]

In this study, the mediopatellar and lateral intra-articular folds were classified according to their vertical and horizontal parts and dimensions of these parts (large or narrow band forms). Frequencies of all types were also determined. Classifications of the MF and LF in the literature include only the vertical parts and no data exist about the horizontal parts of these folds, in terms of definition, frequency, and dimension. We think that these horizontal extensions between the femur and patella have been neglected among other related formations (LF, MF, IPFP, alar fold). We believe that the horizontal parts of the MF and LF and their relation with the IPFP and alar fold should be defined. The synovial membrane surrounding the IPFP extends backwards between the tibia and femoral condyles and forms the alar folds.[2,3,14] We observed that the horizontal parts of the MF and LF extended upwards from the IPFP in the coronal plane between the patella and femur, presenting as a continuous fold with the vertical part of the MF and LF, if existed, or as a separate synovial fold in this region in the absence of a vertical part.

Multiple trauma of the condyle (even of minor type), repetitive flexion and extension, or direct contusion may lead to inflammation and thickening of the fold. Thickening of the fold may cause local irritation or erosion of the hyalin cartilage lining the condyle, which may in turn result in plica syndrome (medial synovial shelf syndrome).[2,8,12,15]

Plica syndrome in adults has been rarely reported in the literature; however, Ege et al.[16] reported that 13 (20%) of 64 adult cases (mean age 42.7 years) undergoing knee arthroscopy had pathologic plicae. In arthroscopic examination of pre-adolescent cases (<13 years), Faraj et al.[17] reported symptomatic plica syndrome in the first place with a rate of 35% (8/23 cases). Symptomatic plica synovialis was detected as the second most frequent pathology by Sarpel et al.[18] with a frequency of 8% in pre-adolescent cases. The authors suggested that, despite being an anatomical component, the plica in the knee joint might be a cause of anterior knee pain in children.[18] However, both studies lacked distinctive data about the relation between the pain and localizations and dimensions of the plicae.

We think that our classification system will facilitate the definition and delineation of MF and LF variations. For instance, the case of Çalpur et al.[13] defined as "united, unresorbed medial and lateral folds" may be re-defined as "a case with broad bands of the horizontal and vertical parts of both MF and LF".

Boven et al.[6] found that 16% of the cases had such a large MF as to cause plica syndrome. In our study, 10% of the MFs and 17% of the LFs had large vertical parts that were in contact with the articular surface of the patellofemoral joint. These cases were thought to be susceptible to plica syndrome. Moreover, in 45% of the cases, the horizontal bands were so large that they covered the lower half of the posterior surface of the patella completely, which might result in squeeze between the femur and patella.

We did not encounter any fenestrated or detached fold neither in the MF nor in the LF, which was de-

fined as type D by Sakakibara and was associated with plica syndrome in 4.4% of the cases (cited by Ieda et al.[12]). We speculate that a plica which is large and has no initial fenestra may become fenestrated due to resorption and, in addition, to friction and squeeze as the child begins to walk.

Ogata and Uhthoff[1] reported a frequency of 33% for MF in fetuses and stated that once they occurred, these plicae never disappeared with age. In the same study, they observed that the mesenchymal tissue in the lateral part of the patella was less than that on the superomedial side, and claimed that this might be due to the lateral transport of the quadriceps tendon and suprapatellar bursa during the developmental period.[1] No study was encountered in the literature regarding the completion of MF and LF resorption. However, two studies mentioned about the resorption process of the suprapatellar fold, which is the other remnant of mesenchymal tissue, during the development of the knee joint. Gülman et al.[19] compared their findings from 50 neonatal cadavers concerning the suprapatellar fold with those of adults reported in the literature and concluded that the resorption of the suprapatellar fold continued during the postnatal period. Zidorn[20] claimed that mechanical factors such as pressure and friction were associated with changes in the suprapatellar fold. We think that this resorption process is also effective for the MF and LF, which are the other remnants of the same mesenchymal tissue in the knee joint. This concept is supported by our study when the data on the presence and dimension of the folds are compared with the morphologic data of adults. The LF (vertical part only) was observed as a broad band in 16.7% of the cases in our study, which has been reported as 1-3% for adults.[1,13] This difference can be explained in two ways: *(i)* the mesenchymal tissue resorption which begins in the intrauterine period continues in infancy, childhood, and perhaps in the adolescence period particularly in the lateral part of the knee joint; and/or *(ii)* the development of the surrounding structures such as the distal end of the femur and the quadriceps mechanism may cause changes in the synovial membrane and related mesenchymal structures. These changes, in turn, may lead to gradual disappearance of the less prominent subgroups of LF with age.

In conclusion, our findings show that the folds of the knee joint in fetuses occupy more place than observed in adults. The duration of fold resorption is not clear, but possibly these folds occupy more place in the early childhood compared to adults. This may be a more frequent cause of knee pain in children. Evaluation of clinical data in various age groups would throw more light on the clinical implications of our morphological results.

References

1. Ogata S, Uhthoff HK. The development of synovial plicae in human knee joints: an embryologic study. Arthroscopy 1990;6:315-21.
2. Netter FH. The Ciba Collection of Medical Illustrations: Vol. 8, Musculoskeletal system part II. Developmental disorders, tumors, rheumatic diseases, and joint replacement. New Jersey: Ciba-Geigy Corporation; 1990. p. 76.
3. Williams PL, Warwick R, Dyson M, Bannister LH, editors. Arthrology. In: Gray's anatomy. 37th ed. New York: Churchill Livingstone; 1989. p. 527-30.
4. Dandy DJ. Anatomy of the medial suprapatellar plica and medial synovial shelf. Arthroscopy 1990;6:79-85.
5. Tindel NL, Nisonson B. The plica syndrome. Orthop Clin North Am 1992;23:613-8.
6. Boven F, De Boeck M, Potvliege R. Synovial plicae of the knee on computed tomography. Radiology 1983;147: 805-9.
7. Dai SY, Lin DX, He TQ, Li HY, Meng XY, Sun B, et al. Synovial plica syndrome of the knee and related anatomy. Chin Med J 1988;101:529-32.
8. Kim SJ, Choe WS. Pathological mediopatellar plica found in the knee of an infant. Arthroscopy 1998;14:620-3.
9. Bae DK, Nam GU, Sun SD, Kim YH. The clinical significance of the complete type of suprapatellar membrane. Arthroscopy 1998;14:830-5.
10. Kim SJ, Shin SJ, Koo TY. Arch type pathologic suprapatellar plica. Arthroscopy 2001;17:536-8.
11. Kim SJ, Kim JY, Lee JW. Pathologic infrapatellar plica. Arthroscopy 2002;18:E25.
12. Ieda Y, Kotani A, Ishii Y. Bilateral plica synovialis mediopatellaris syndrome: a case report. J Orthop Sci 2003;8: 218-21.
13. Çalpur OU, Copuroğlu C, Özcan M. United unresorbed medial and lateral plicae as anterior mesenchymal synovial septal remnant. Knee Surg Sports Traumatol Arthrosc 2002;10:378-80.
14. Netter FH. The Netter Collection of Medical Illustrations. Vol. 8, Musculoskelatal system part I. New Jersey: Novartis Pharmaceuticals Corporation; 1997, p. 96-7.
15. Subotnick SI, Sisney P. The plica syndrome. A cause of knee pain in the athlete. J Am Podiatr Med Assoc 1986; 76:292-3.
16. Ege G, Akman H, Ertem E. Medial patellar plika send-

romu. Tanısal ve Girişimsel Radyoloji 2002;8:93-6.
17. Faraj AA, Schilders E, Martens M. Arthroscopic findings in the knees of preadolescent children: report of 23 cases. Arthroscopy 2000;16:793-5.
18. Sarpel Y, Özkan C, Toğrul E, Tan I, Gülşen M. Arthroscopy of the knee in pre-adolescent children. Arch Orthop Trauma Surg 2007;127:229-34.
19. Gülman B, Kopuz C, Yazıcı M, Karaismailoğlu N. Morphological variants of the suprapatellar septum. An anatomical study in neonatal cadavers. Surg Radiol Anat 1994; 16:363-6.
20. Zidorn T. Classification of the suprapatellar septum considering ontogenetic development. Arthroscopy 1992;8: 459-64.