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SECTIONAL ANATOMY OF PLASTINATED KNEE JOINT: A BOON FOR RADIOLOGISTS

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Abstract: The exact knowledge of the topographical anatomy is not only a pre-requisite but also facilitates accurate clinical diagnosis during MRI, CT and ultrasonography. It becomes more fascinating if the anatomical specimen being used to study is dry, odourless, non toxic and not a wet specimen with formalin fumes. Such specimens can be procured by using a novel processing technique called plastination. Thus the present study was undertaken to prepare coronal and sagittal knee region plastinates for studying sectional anatomy of knee joint and to compare them with MRI images of the same. A total of 4 knee joint specimens were collected, washed, cleaned and fixed in 5% formalin. Coronal (1cm) and sagittal (1 cm) slices were made, plastinated using S-10 silicon technique and compared with MRI images of the same. All the structures were exactly corresponding to the MRI images. Thus plastinated coronal and sagittal sections of the knee are ideal as teaching tool for studying sectional anatomy of knee not only because of their instructional value but their durability, ease of handling, transportation to operation theatre and a ready reference material at the work place.Plastinated knee specimens can serve as excellent educational tool for the undergraduate and postgraduate students of anatomy, radiology and orthopedics as they are dry, odorless, nontoxic with good structural preservation and higher instructional value. Fresh knee region when plastinated were esthetically superior in terms of color, dilatation and flexibility thus making them ideal for teaching and hands-on experience.

Key words: Cross-Sectional Anatomy; MRI; Knee; Plastination, S-10

I. INTRODUCTION

Sectional anatomy has had a long history, which reached a zenith in the nineteenth century only to decline in the early twentieth, and is now enjoying a renaissance because of advances in radiological techniques such as computed tomography and magnetic resonance imaging. This necessitates the need of including teaching of sectional anatomy as an integral part of medical curriculum at various levels [1].

However formalin fixed wet sections deteriorate with time [2,3]. To overcome these problems we decided to plastinate sections of various anatomical specimens as these specimens offer several advantages over other methods of preservation because they are anatomically precise, clean, dry and easy to handle [4]. Plastinated slices provide an excellent tool for teaching anatomy, pathology and radiology [5-7] for patient education, and potentially as an augmentation to MRI and CT analysis [8,9]. These plastinated sections show anatomical structures in multiple planes and are effective for teaching anatomical spatial relationships, something that students often find difficult to comprehend [10].

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Knee joint being the largest, most complicated joint, vulnerable both to acute injury and osteoarthritis, understanding its anatomy is fundamental in understanding any subsequent pathology. A review about image analysis of the anterior cruciate ligament (ACL) anatomy and its application to ACL reconstruction surgery reported that three-dimensional image analysis of the ACL anatomy and its application to the navigation system is becoming more prevalent and reliable for advancing the anatomic studies related to the native ACL and the ACL reconstruction procedure. Thus Plastinated knee sections can not only be of immense help in radiographic analysis but can also provide hands-on experience to various orthopedicians. Thus the present study was undertaken to prepare plastinated coronal and sagittal sections of knee region and compare them with the MRI images of the same which to the best of our knowledge has not been reported in the literature so far.

II. MATERIALS AND METHODS

Knee specimens were collected from the cadavers being used in the Department of anatomy, AIIMS, New Delhi. Each specimen (25 cm in length) was thoroughly washed with running water and rinsed with normal saline injection through the femoral artery followed by heparin (25,000 I.U. in 5ml) diluted with distilled water in a proportion of 0.2 in 5ml. 5% formalin was injected through the femoral artery for fixation. Specimens were submerged in 5% formalin for 1-2 weeks for a better fixation. Formalin fixed specimens were washed in running tap water for one to two days to remove the excess formalin, cooled to -40°C in order to harden them up and then sliced in coronal (1cm) and sagittal (1cm) planes with the band saw. Cut sections were transferred to 100% cold acetone at -20°C. Acetone concentration was measured daily with acetonometer and acetone changes made when concentration reached around 90%. Dehydration was considered complete when water content was below 1% for three consecutive days. After this specimens were immersed in the silicone resin S10 with S3 Catalyst for 24 hours [11]. They were then subjected to a forced impregnation where the pressure was reduced gradually by using a vacuum pump. The rate of impregnation was monitored by the rate of acetone bubbles which came on the surface. The specimens were kept immersed in the polymer for one day before taking them out. They were finally gas cured in a curing chamber by passing S6 vapour. After the specimens were dry on touch, they were enclosed in polythene bags for the final curing. The various sections demonstrated the internal features and were compared with MRI images of the same.

III. RESULTS

The work resulted in coronal and sagittal sections of `knee, exactly corresponding to the MRI images serving as teaching material for radiologists without any potential and chemical hazards, especially from formaldehyde. They provided excellent anatomical bone detail, demonstrating organ position, shared structures, and vascular anatomy. The specimens could be stored in the radiology department without wet formalin jars for ready reference.

[A.] In the coronal slices of knee region the following structures were seen:

Posterior-to-anterior coronal anatomic sections demonstrated the posterior capsule, the popliteus tendon, the cruciate ligaments and menisci, the collateral ligaments and the extensor mechanism **[Fig.1]**. This plane also displayed the posterior femoral condyles, which are common sites of articular erosions. The cruciate ligaments, although displayed to best advantage in the sagittal plane, were also identified on coronal sections [**Fig.1**]. The oblique popliteal ligament and arcuate popliteal ligament defined the posterior capsule.

The **LCL (fibular collateral ligament)** was seen as a cord stretching from its insertion on the fibular head to the lateral epicondyle of the femur. It was separated from the lateral meniscus by the thickness of the popliteus tendon. At the level of the femoral condyles, the **meniscofemoral ligaments** (the ligaments of Wrisberg and Humphrey) were observed as thin bands extending from the posterior horn of the lateral meniscus to the lateral surface of the medial femoral condyle. The **PCL** was seen as a circular structure on anterior and mid-coronal sections. On posterior coronal images, the triangular attachment of the PCL was differentiated as it fanned out from the lateral aspect of the medial femoral condyle. **The MCL, or tibial collateral ligament**, was identified on mid-coronal sections **[Fig 1.]** anterior to sections

in which the femoral condyles appeared to fuse together with the distal metaphysis. The MCL was seen as a band extending from its femoral epicondylar attachment to the medial tibial condyle. It consisted of superficial and deep layers attached to the periphery of the medial meniscus.
The body and the anterior and posterior horns of the medial and lateral menisci were seen as distinct segments and not as opposing triangles as on sagittal sections.

[B.] In the sagittal section of knee region the following structures were seen:

Bony structures- Patella, Lateral condyle of femur and lateral condyle of tibia **[Fig.2]**
Muscles- Popliteus, Gastrocnemius lateral head and Plantaris **[Fig.2]**
Menisci and ligaments- Patellar ligament and both the horns of lateral meniscus **[Fig.2]**
Infrapatellar fat pad and suprapatellar bursa were nicely seen in the mid- sagittal section **[Fig.2]**. Sections in the sagittal plane are key in evaluating meniscal anatomy for both degenerations and tears.
Other structures observed in the sagittal plane were the posteromedial and posterolateral corners, the patellar and quadriceps tendons, Hoffa's fat pad and plicae.
The patellofemoral compartment, quadriceps, and patellar tendon were demonstrated on midsagittal section **[Fig.2]**. The suprapatellar bursa (pouch) extended 5 to 7 cm proximal to the superior pole of the patella **[Fig.2]**. Superficial medial dissection displayed the conjoined pes anserinus tendons (semitendinosus, gracilis, and Sartorius). On the lateral aspect of the knee, the LCL and the more posteriorly located fabellofibular ligament (structures of the posterolateral corner of the knee) were seen.

- The ACL and PCL were best displayed on sagittal slices. The LCL, or fibular collateral ligament, and the biceps femoris tendon were seen on peripheral sagittal sections. .
- On medial sagittal section, semimembranosus tendon and muscle was seen posteriorly. The vastus medialis muscle made up the bulk of the musculature anterior to the medial femoral condyle. The anterolateral femoral articular cartilage was frequently the site of early erosions or attenuation in osteoarthritis (trochlear groove chondromalacia).
- On medial slice approaching the intercondylar notch, the separate anterior and posterior horns of the medial meniscus were seen. When sagittal sections were viewed in the medial to lateral direction, the PCL was seen before the ACL.
- Portions of both cruciate ligaments were observed on the same sagittal section. On midsagittal sections, the quadriceps and patellar tendons were seen. On intercondylar sagittal slice, the popliteal vessels were seen in long axis, with the artery in an anterior and the vein in a posterior position.
- On extreme sagittal sections, the conjoined insertion of the LCL and the biceps femoris tendon on the fibular head were identified. The lateral head of the gastrocnemius muscle was seen posterior to the fibula. The popliteus tendon was seen between the capsule and the periphery of the lateral meniscus.

All the structures were exactly corresponding to the MRI images. The plastinated slices displayed superior differentiation between musculature compared to the scans. Thus, the coronal and sagittal sections of the knee are ideal for studying sectional anatomy of knee which is needed for diagnostic as well as for research and teaching purpose.

IV. DISCUSSION

Anatomy is a fundamental educational science in Medical Universities. It has been involved in radiological instructions for medical students for decades [1]. Most clinicians view internal anatomy with the aid of radiographic images and procedures. Proper interpretation of these images presupposes a detailed knowledge of anatomy. Anatomy teachings should implement a number of clinical procedures, pathological observations and diagnostic methods into the course resulting in a structured program of clinically based teaching of gross anatomy to second- and third-year medical students. The recently developed method of E12 epoxy resin sheet plastination has expanded the learning process twofold, firstly as a developmental microscopy teaching aid enabling us to link histological slides directly to gross anatomical specimens and secondly as a radiographic training tool in the correlation of clinical imaging techniques of magnetic resonance (MRI) and computed tomography (CT) with the teaching of gross anatomy. The direct comparison between E12 serial sectioned cadaver specimens and the equivalent MRI and CT images provides the student with a much clearer understanding of anatomical structures in relation to clinical diagnosis [9].

Radiography has proved particularly valuable in the detection of the early stages of deep-seated disease, when the possibility of cure is greatest. During these early stages there is little departure from the normal. Hence knowledge of the earliest detectable variations, that is, of "the borderlands of the normal and early pathological..." is of great medical importance. Radiographic diagnosis is the most important method of non-destructive testing of the living body. With the rise of modern imaging methods, the demand for sectional anatomy has increased and requires that it should be integrated into medical curriculum as vital component during undergraduate and postgraduate levels. Such sections should also be available in later phases of the curriculum when students deal with patient-oriented material.

In the study of anatomy, the use of gross specimens and other biological material is mandatory. Decay of this material is an impediment to all morphological studies, teaching, and research. Thus essential part is an excellent preservation of the biological material being used in teaching for it to be used as an educational tool. Plastinated specimens are clean and odorless, require minimal aftercare & can be stored on shelves or in display cases for a longer duration. As fully cured specimens are durable and do not require 'wet' storage, plastination provides us with the opportunity both to extend the life of this material, and additionally maintain effective student/specimen interaction. The dry plastinated specimens also become transportable.

As knee joint is one of the most important joint of human body, understanding the anatomy of the joint is fundamental in understanding any subsequent pathology. The exact knowledge of the topographical anatomy of knee joint is not only a pre-requisite but also facilitates the accurate clinical diagnosis of various knee disorders using imaging techniques like MRI, CT and sonography. Interpretation of radiological images need anatomical details in multiple planes, something that students often find difficult to master [12]. In the present study the coronal and sagittal plastinates of the knee joint corresponded well to the MRI images and thus are ideal for studying sectional anatomy of knee for understanding its pathology for clinical diagnosis. In future they will be preferred over wet specimens not only because of their instructional value but their durability, ease of handling, transportation to operation theatre, a ready reference material at the work place and positive impact on learners.

Currently we have plastinated the 1cm thick sections by S-10 procedue. We are planning to prepare in future 4-5mm thick sections by epoxy technique which gives more accurate details.

V. CONCLUSION

Sheet plastination is currently used to produce anatomical sections of different body structures, allowing one to study and teach their topography in an anatomically correct state. Correlation with computed tomography (CT) and magnetic resonance imaging (MRI) techniques gives more insight into their anatomy. This combined approach provides a unique anatomical insight and is a valuable addition to other teaching tools used by medical students, radiologists and anatomists.

REFERENCES

[1] Miles KA, "Diagnostic imaging in undergraduate medical education: an expanding role", Jul;60(7):742-5,2005.
[2] Tiedemann K.," A silicone-impregnated knee joint as a natural model for arthroscopy", J Int Soc Plastination, 2(1):13–17, 1988.
[3] Kerns WD, Pavkov KL, Donofrio DJ, Gralla EJ, Swenberg JA, "Carcinogenicity of formaldehyde in rats and mice after long-term inhalation exposure", Cancer Res, Sep;43(9):4382–92, 1983.

[4] Steinke H, Rabi S, Saito T, Sawutti A, Miyaki T, Itoh M, Spanel-Borowski K, "Light-weight plastination", Ann Anat, Nov 20;190(5):428-31, 2008.

[5] Bickley HC, von Hagens G, Townsend FM, "An improved method for the preservation of teaching specimens", Arch Pathol Lab Med, Dec105(12): pp. 674-6,1981.

[6] Dawson TP, James RS, Williams GT, "Silicone plastinated pathology specimens and their teaching potential", J Pathol 162: pp. 265-72,1990.

[7] Aufdemorte TB, Bickley HC, Krauskopf DR, Townsend FM, "An epoxy resin and silicone impregnation technique for the preservation of oral pathology teaching specimens", Oral Surg Oral Med Oral Patho,. 59: pp. 74-6,1985.

[8] Entius CAC, van Rijn RR, Zwamborn AW, Kleinrensink GJ, Robben SGF, "Influence of Formaldehyde/Phenol Fixation on MRI of the Knee and Correlation with Plastinated Slices", 9th Int Conf Plast, Trois-Rivières, Québec, Canada. 13(2): p. 38,1998.

[9] Magiros M, Kekic M, Doran GA, "Learning relational anatomy by correlating thin plastinated sections and magnetic resonance images: preparation of specimens", Acta Anat (Basel), 158(1): pp. 37-43,1997.

[10] Lufler RS, Zumwalt AC, Romney CA, Hoagland TM, "Incorporating radiology into medical gross anatomy: does the use of cadaver CT scans improve students' academic performance in anatomy?" Anat Sci Educ., Mar-Apr;3(2):56-63, 2010.

[11] Henry RW, Janick L, Henry C, "Specimen Preparation for Silicone Plastination", J Int Soc Plastination, 12: pp. 13-17,1997.

[12] Cook P, "Sheet plastination as a clinically based teaching aid at the University of Auckland", Acta Anat (Basel), 158(1):33-6, 1997.

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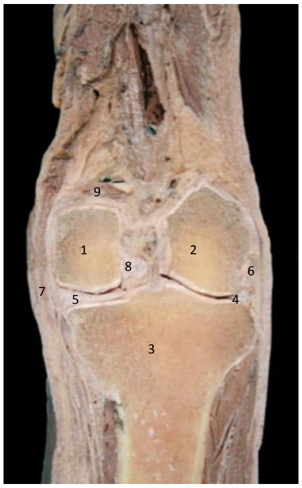
Figure 17. Coronal section of (a). Plastinated Left knee joint and (b). Corresponding MRI image

(a).



(b).

1. Medial Condyle of Femur
2. Lateral Condyle of Femur
3. Tibia
4. Lateral Meniscus
5. Medial Meniscus
6. Lateral Collateral Ligament
7. Medial Collateral Ligament
8. Posterior Cruciate LIgament
9. Lateral Head of Gastrocnemius

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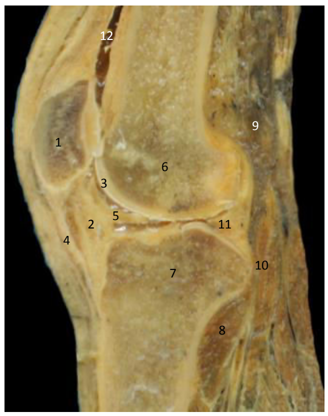
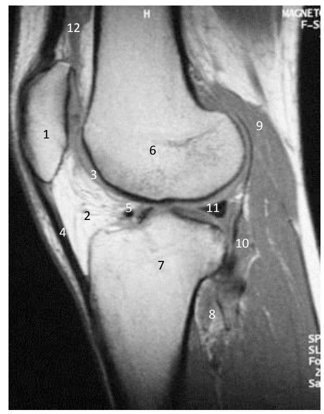
Figure 18. Mid-sagittal section of (a). Plastinated left knee joint and (b). Corresponding MRI image

(a).





(b).

1. Patella
2. Infrapatellar Fat Pad
3. Articular Cartilage
4. Patellar Ligament
5. Anterior Horn of Lateral Meniscus
6. Lateral Condyle of Femur
7. Lateral Condyle of Tibia
8. Popliteus Muscle
9. Gastrocnemius Lateral Head
10. Plantaris
11. Posterior Horn of Lateral Meniscus
12. Suprapatellar bursa