Finite element analysis of patellofemoral joint prosthetics

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Abstract. Prosthetics have been existed from the times of the old. Prosthetics were utilized numerous applications: work, restorative appearance and aesthetics from time of the Egyptians, profound feeling of being entirety. Chronic knee conditions such as Chondromalacia patella is one of the knee joint is an disability that influences the ligament of the patella and is additionally regularly called sprinters knee. It cause torment on the patellar part of knee and furthermore require supplanting medical procedure for influenced knee with counterfeit segments. Kneecap typically dwells over the front of your knee joint. At the point when you twist your knee, the posterior of your kneecap floats over the ligament of your femur, or thigh bone, at the knee. Ligaments and tendons connect your kneecap to your knee thigh muscle. At the point when any of these parts neglects to move appropriately, it can make your kneecap rub facing your thigh bone. The substitution of the entire knee is a tedious and maximally obtrusive procedure. Henceforth a patellofemoral embed can help in just be restricted cure but then take care of the issue caused due to chondromalacia . The patellofemoral CT images will be segmented and smoothed using MIMICS 21.0 software. This allows for meshing and assigning material properties to the bone to check how the bone interacts with the implants. Material properties are assigned using ANSYS Mechanical APDL 18 .The mechanical properties of two implant materials are compared to view the results. The scope of the project is that it is beneficial in the prosthetic industry as it can provide patients with the less painful method of replacement and hence they will be able to do their normal daily activities. Which can be for the betterment of athletes and runner and other targeted condromlacic patients. The aim is to carry out Finite Element Modeling and analysis of Prosthetic for patellofemoral region. The objective is to carry out segmentation and thresholding of a CT image. Studying the various material properties that will used for prosthesis for the Patellofemoral region and to undertake a comparative Finite Element Analysis of the compatible materials. The comparison between bio-compatible materials like carbon fiber and HDPE and check as to which would be the better implant material, its feasibility and availability and also to design and create a 3D model of the is the main aim of the study.

1. Introduction
Over the span of exploring the degenerative changes which happen in the ligament of the patella we thought that it was important to audit the typical life systems of the patello-femoral joint, and to set up the exact territories of ligament that support load in different places of that joint as said by Hently et al (2016)[1]. According to Goodfelow et al (1941) [2] gave an incredible depiction of the shifted types of the patella, and by an assortment of circuitous techniques for assessment, including plain
radiography, differentiate arthrography and sequential separating of solidified joints, he gave a
general image of the evolving example of contact which happens with development of the knee. His
technique didn't permit a succession of observations in a few situations in any one joint, and his
conclusions were by derivation from the contact zones watched in a few joints, each in an alternate
position. Besides, his examinations on cadaveric joints were made in the emptied state, and no genuine
endeavor was made to imitate the powers about the knee that settle it throughout everyday life and to
a few degree decide the overall places of its parts. The accompanying depiction depends on
perceptions made on cadaveric joints in which the powers of typical weight-bearing were firmly
recreated. Over the span of researching the degenerative changes which happen in the ligament of the
patella we thought that it was important to audit the ordinary life structures of the patello- femoral
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2. Materials and Method

2.1 CT image acquiring

CT images were aquired from database of SRM Institute of science and Technology. The
specifications are :
Subject Age:23 years
No.of slices :247
Types of CT: knee CT
Width :251
Slice height: 355 pxl
Size=0.684 mm
The CT that was acquired was input into the MIMICS 21.0 using. diacom file and was imported in the
software. Bradleyab et al. (2005), the overall public may not be progressively presented to the
innovation, yet we can be certain that it is grinding away in the background in a developing number of
uses for tweaked items, made to suit a person's life systems or inclinations [6].
2.2 Organising image

On the off chance that there are all the more no of CT pictures, at that point it might require some investment for further procedure and pointlessly it will make issue in recreation of 3D model. So we need to streamline the quantity of CT pictures to decrease the remaining burden and improve the proficiency through "Compose Images". In the "Arrange Images" interface we can pick pictures according to our prerequisite in MIMICS venture which ought to be obvious and utilized while working with MIMICS. Starly at al. (2005) has done deal with the advancement of biomimetic bone structures which thus would be utilized in the plan of heterogeneous platform structures. The CT/MRI picture based remaking gives a strategy where the external state of the platform structure can be recovered for proper anatomical fitting and compatibility. CAD models are utilized as the reason for readiness, multi material frameworks can likewise be created for tissue building applications [5]. Milovanović et al. (2007) Survey was done for the types of the chondramalciac patients and reference was provided. [7]. Wang et al. (2009), they found that machining cortical bone sections before CT examining is a compelling strategy for precision assessment of CT-based bone reconstruction to understand the anatomy[8]. Chizari et al. (2009), The investigation utilizes a limited component strategy to dissect an anatomically definite ACL recreated knee of a 22 years of age understanding three months after activity, utilizing information got from a CT examine. The model considered a kinematic requirement and parts cooperation at the ligament unite and tibial passage were implemented giving an insight on how to segregate the images based on various conditions[9].

Figure 1. Flowchart showing steps for segmentation of CT Image using MIMICS.
2.3 Thresholding
As various associations will have distinctive dim an incentive in CT pictures, so it is required to set precisely the edge esteem. We can watch the CT pictures to see the necessary piece of the separated associations when set the edge esteem. The edge worth ought to be kept as lower as conceivable to stay away from the clamor. A decent edge an incentive for Mimics is around 270 (Hounsfield scale). Thresholding procedure appeared in CT pictures are a pixel guide of the direct X-beam constriction coefficient of tissue. This scale is known as the Hounsfield (HU) scale. Thresholding dependent on Hounsfield scale was utilized to isolate each piece of the knee including bones and the typified delicate tissues volume. So as to incorporate all the cortical bone at the knee bone structure and avoid the ligament districts, a lower breaking point of 485HU and a maximum cutoff of 1467HU were characterized. The delicate tissues area was created bookkeeping a scope of - 188HU to 3071HU. In the thresholding the bone structure are chosen which can see with green shading. In this procedure we select the bone structure for which we need to create 3D model. We select just that territory of the knee to produce the model. So thresholding is the choosing procedure of the bone structure. Jianping et al (2009), We found that machining cortical bone portions preceding CT examining is a viable technique for exactness assessment of CT-based bone remaking. As the form of human bone was of complex geometry, there was no brilliant standard to look at the distinction of complex surfaces between genuine human bone and imitation one. During the whole geometrical remaking process, the CTimaging methodology is known to be of exceptionally high accuracy, with basically no geometric amplification error [10]. Ming-Ching et al. (2010), The total surface work is developed by combining every one of the outputs in the request augmenting common covers. We have proposed a dependable way to deal with precisely process crude laser sweeps to deliver a reliable ground truth data set. By lessening the detecting and test blunders in the combination procedure, the subsequent model has low variety and brilliant repeatability, which is helpful for approving the MRI estimations of the knee cartilage [11].

2.4 Region developing and Region growing
This order is utilized when the chosen area is to be taken from entire figure as in beneath figure it appeared by cyan shading which will be mulled over as opposed to taking entire part. The area developing procedure permits parting the division in various and isolated parts. Corresponding each part to one veil that can be recognized by the diverse applied cover's hues. For that geometrical detachment to occur, the contiguous covers must not be associated with any lingering pixel. These activities were performed in all cuts produced at the CT filter. For the total meaning of the bone knee structure and delicate tissues, various areas (tibia, femur, patella, fibula, ligament join and delicate tissue) were characterized. Kamala and Kumara (2013), CT/MRI pictures got the more precise geometry of distal femur and proximal tibia bone and the idea of figuring out so as to improve the embed plan and make it more customized [12]. George (2010) Predicting the effects of knee focal articular surface injury with a patient specific finite element model showed the study of the various injuries caused in knee region and finite element analysis study of these regions [13].

2.5 3D Remaking
In the wake of having done every above advance "Ascertain 3D" from the "Division" Menu. The 3D structure of the femur can be envisioned plainly. The created district veils were utilized to create 3D models for each the bones and typified delicate tissues volume. The 3D reproduction depends on 3D introduction procedures that change the 2D pictures (cuts) in a 3D model. For this remaking case, dark qualities addition was utilized related with the exactness calculation for accomplishing a progressively precise dimensional portrayal of the knee structure. Shell and triangle decrease, separately, were utilized for dispensing with little in corporations and diminishing the quantity of work components. Every district was then recreated to get every one of the bones and embodied delicate tissues volume that geometrically characterizes the knee structure. This was done with respect to study of Sanjay et al (2012) [14].
2.6 Analysis of materials properties using ANSYS
After segmentation the structures were uploaded ansys in an Iges file and the material properties are assigned to the lower femur portion directing to the patella. The materials carbon filer, and high density polyethylene tested After uploading the image in ANSYS Apdl:

PreProcessor > Defining material properties:
HDPE : Poisson ratio : 0.4
Elastic modulous: 0.5-1.2 GPa
Strength : 15-40 Mpa
Carbon fiber : Poisson ratio : 0.2
Elastic modulous: 10.8 GPa
Strength : 68 Mpa
Solution> define load>Structural or force\moment. Post Processing > Solve > plot .Plot controls> animate.

3. Result

Figure 2. Segmentation of patellar region.

Figure 3. Meshing of knee using Remesh tool.
4. Conclusion
The patella was segmented using region growing in the Mimics 21.0 software and meshed using remesh tool using 3 matic 11.0 software in integration with Mimics 21.0. The smoothening and the rendering of the mesh was done using 3 matic. After the meshing then the dicom file has to be converted to IGES file that could be used to import in ANSYS Mechanical APDL. The material properties were assigned and load was distributed in ANSYS and the stress assigned was Von misses stress in order to calculate the solution for visualization mechanical change in the patella. The result could be visualized using post processing steps that include the plot controls and animate solution. The HDPE showed more efficiency in regard to strength and compatibility but further more exerch needs to be dome to find out long term effects.

5. Discussion
The investigation of the mechanics and pathology if patellofemoral joint and Pediatric ramifications of patellar precariousness as said by Hasler et al (2016)[15] was studied. Carbon fiber utilized as a medicinal embed for patellar imperfections. A patella (knee top) embed for obsession to the rest of the segment of a characteristic patella and for sliding over a femoral articulating part, the embed including an upper surface, normally curved, for sliding over the femoral articulating part, commonly a section, and an inward under surface for obsession to the rest of the segment of the regular patella. Additionally gave is an instrument to setting up the common patella to acknowledge a patella embed and a strategy for precisely fixing the patella embed. As said by G Bently et al (2008)[16] the materials carbon fiber and HDPE could be utilized for the embed. The material properties of these have been utilized to embrace comparative examination and later on structuring of the embed and the 3D printing of the embed will done. Hence the comparison was done for the materials that could potentially be used for implant in patellofemoral region. Also comparing between normal and diseased conditions.
6. References

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