

## Histological Assessment and Grading Of Cartilage Damage at the Time of Patient Undergoing a Total Knee Replacement

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### Abstract

**Background:** Beginning of degenerative cartilage damage heralds the onset of primary osteoarthritis of the knee joint. The pain associated with the cartilage damage occurs only after a certain degree of cartilage loss. After the damage exceeds a certain level, the pain and disability drive the patient to seek an active treatment. Soon, a stage is reached when patient is not able to tolerate the pain and agrees for a total knee arthroplasty.

**Objectives:** The study aims to find out the histological stage, when surgeon and the patient reach a clinical end point where both the patient the surgeon reach to a consensus for a total knee arthroplasty.

**Materials & Methods:** 50 consecutive patients posted for a total knee arthroplasty at a tertiary care center with a diagnosis of primary osteoarthritis were enrolled in the study from June 2013 to June 2015. The biopsy samples were obtained from the medial compartments of the discarded joint after the Arthroplasty. After processing, the biopsies were studied under light & polarised microscopy. The histologic grading of these lesions was done using the OARSI criterion.

**Results:** After applying the exclusion criteria, (97.62%) showed a grade 3 or grade 4 (42.85% & 54.76%) cartilage damage respectively. One patient (2.38%) had an OARSI grade 5 damage.

**Conclusion:** The study gives a pointer to whether the TKA is being done at an earlier stage wherein the joints could have been preserved with the repair surgeries.

**Key Words :** Osteoarthritis, Histology, Arthroplasty, OARSI grading, Medial Compartment.

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### I. Introduction

The Articular Cartilage of the knee joint is a specialised tissue designed to protect the articular surfaces of the bone. Certain diseases, aging and injury lead to a damage to the articular cartilage leading to an onset of Osteoarthritis (OA).

Till a certain stage of the cartilage damage there is no pain or a tolerable pain which can be relieved by physiotherapy, analgesics or the various cartilage repair surgeries.

However, a significant damage & an intolerable pain and disability calls for the decision of a total knee replacement.

There is no research study till now, showing the extent of the histological damage of the cartilage at this stage. The different compartments of the knee joint are in different stages of osteoarthritis of which the medial compartment is the most frequently affected, in almost all the cases of a tricompartmental Osteoarthritis.

The purpose of this study is to do a histological analysis of the cartilage tissue from the medial compartment of the knee joint & to evaluate the histological grading of the cartilage damage according to the Osteoarthritis Research Society International (OARSI) criterion.

### II. Materials & Methods

#### *Aims and objective*

To grade the most extensively damaged and representative cartilage region with the OARSI criteria from the medial compartment in knees undergoing TKA.

To correlate OARSI grading with clinical endpoint, when the surgeon and patient both came to a consensus for a Total Knee Arthroplasty (TKA).

#### *Sample collection*

The Patients listed for TKA at the Orthopaedic Department from June 2013 to June 2015 at a tertiary care Hospital with Osteoarthritis of the knee joint were registered for the study, after receiving a clearance from the Institutional Review board .

156 patients consented to the study from which a total of 50 samples were obtained after applying the Inclusion & Exclusion criteria. From these cases 42 samples were analysed having excluded 8 cases with an inflammatory OA.

#### *Inclusion criteria*

- Tricompartmental OA
- Degenerative OA
- Medial compartment – main compartment affected.

#### *Exclusion criteria*

- Bone-on-bone OA
- Inflammatory and Traumatic OA
- Tricompartmental OA with the medial compartment lesions < 2cm<sup>2</sup>

A section for the histologic assessment was taken from the most representative area of the medial femoral condyle, perpendicular from the articular surface to bone plate.

The sections were kept for decalcification followed by staining by Hematoxylin& Eosin(H&E) and the Alcian blue stains & examined under the light & polarized microscopy.

AnOARSIgrading was carried out on the processed biopsies.

### **III. Results**

*Age & Sex:* The median age at presentation in present study was 55 years. The range being 45 years to 80 years. 11 (26%) patients were < 60 years of age of which 28(56%) were males and 22 (44%) were females. (Table 1)

*Presenting symptoms:* The patients chiefly presented with Pain and difficulty in walking in 78% of cases, & pain during rest in 16% cases. Swelling was present in 6% of the cases.

*Body Mass Index:* 23 (55%) patients had a BMI < 30(Table 2)

*Histopathology:* According to OARSI classification 18 patients had a histologically grade-3 cartilage damage while 23 patients had grade-4 cartilage damage while only 1 patient had a grade-5 damage.(Table 3)

Hence 41 patients (97.62 %) had a OARSI grade 3 or 4 lesion & only 1 patient representing 2.38 % presented with a grade 5 lesion.

### **IV. Discussion**

The knee joint is one of the most complex & strongest joints in the human body. The joint-forming surfaces of each bone are covered in a thin layer of hyaline cartilage.

The Articular cartilage of the knee joint is a specialised form of hyaline cartilage which transforms the articulating ends of the bones into lubricated, wear-proof, slightly compressible surfaces exhibiting a very little friction.

The articular cartilage comprises of cells called chondrocytes & a highly specialized extracellular matrix (95% of volume). The ECM is solid, firm, pliable & comprises of collagen (mainly type II), Glycosaminoglycans (GAGs) for Chondrocyte nutrition, along with Proteoglycan aggregates which are important for weight bearing.<sup>[1]</sup>

A Large ratio of GAGs to type II collagen fibres in the cartilage matrix allows for the diffusion of substances between blood vessels in connective tissue & the dispersed chondrocytes.

On histology the articular cartilage is 2-5mm thickness in adults & is divided into four layers according to the structure of chondrocytes & the extracellular matrix, followed by the subchondral bone.<sup>[1,2]</sup>

1. Superficial or tangential zone- Chondrocytes are small, flattened & parallel to the surface. The most superficial part (lamina splendens) is devoid of cells.

The Collagen fibres in the matrix are very fine & run parallel to the free surface in fascicles.

2. Intermediate or transitional zone- contains round chondrocytes randomly distributed within the matrix. Collagen fibrils are less organised and arranged obliquely to the surface.

3. Deep or radial zone- comprises of small round chondrocytes arranged in short columns perpendicular to the free surface of cartilage. The collagen fibrils are positioned between columns parallel to the long axis of bone.
4. Calcified zone - comprises of calcified matrix with the presence of small chondrocytes, separated from the radial zone by undulating heavily calcified line called tidemark.

The Articular cartilage is frequently injured but has a limited capacity for repair attributable to avascularity of cartilage, immobility of the chondrocytes, & a limited ability of the mature chondrocytes to proliferate. <sup>[1,2]</sup>

Hence the focal articular cartilage defects are progressive leading to a deterioration of the cartilage leading to osteoarthritis.

In addition to the normal degenerative changes associated with aging, the hyaline articular cartilage of the knee joint can be damaged following a traumatic Injury, accident, or a sports injury, which can progress to an early Osteoarthritis if neglected.

#### *Cartilage histopathology grading system ( OARSI)*

The system was evolved to have a comprehensive and reproducible histopathology grading scale with universal acceptance, which can be used as a research tool for both comparison of osteoarthritis (OA) histopathology data, and in reference to other OA modes of imaging such as X-ray or magnetic resonance imaging (MRI).<sup>[3,4]</sup>

The system evolves over the other systems such as the OA Histological Histochemical Grading System (HHGS) introduced by Mankin et al. in 1971.<sup>[5,6]</sup> The reproducibility of the HHGS scoring system has been described as inadequate and there is inconsistent opinion regarding the reliability.<sup>[6,7,8,9]</sup>

The Osteoarthritis Research Society International (OARSI) through the establishment in 1998 of an OA Working Group introduced the Osteoarthritis Cartilage Histopathology (OACH) scoring system.<sup>[3,4]</sup>

The OARSI system scores the extent of cartilage damage into grades & stages.

A Grade is defined as the depth of Osteoarthritis progression into the cartilage & is assessed by noting the most advanced lesion present within the cartilage irrespective of its horizontal extent.

Stage is defined as the horizontal extent of the cartilage involvement within one side of a joint compartment irrespective of the underlying grade.

Score is defined as assessment of combined OA grade and OA stage & represents a combined assessment of the OA severity and extent.

OA severity is divided into six grades.<sup>[3,4]</sup>

Grade 0 is the normal grade with an intact surface. (No OA activity seen )

Grade 1 Uneven but intact surface with presence of surface fibrillations (< 10% surface involvement)

Grade 2 Surface Discontinuity with presence of superficial zone fibrillations or abrasions with a loss of matrix (10 - 25% involvement)

Grade 3 Presence of vertical fissures (simple /branched) (25 -60% involvement)

Grade 4 Presence of erosion with superficial zone delamination & mid zone excavation. (> 60%)

Grade 5- Cartilage denudation with intact underlying bone surface

Grade 6 – Subchondral bone changes

The results in our study reveal a very high percentage of the patients in the OARSI grade 3 or 4. These are a stage of the disease with a maximal disease activity that may result in pain not tolerable to the patient. However it might also signify a stage where the knee preservation surgeries could delay a total knee replacement.

The mean age of 60 years is a relatively early age for undergoing a TKA & should be delayed looking at the increasing life expectancy.

The study might act as a pointer to indicate that the patients and the surgeons are reaching to a consensus for TKA relatively early probably owing to a lack of awareness amongst the surgeons and patients towards knee preservation surgeries.

**Shortfalls of the study:** A Clinical and radiological correlation with the OARSI grading was not done in the study & can be taken up in the future such studies.

The study does not document whether the preservation surgeries were Offered to the patient as an alternative mode of treatment.

**Future directions:** Further studies in this direction can aim to identify the primary Source of pain in OA, & the osteoarthritis phenotypes which can be the Cartilage, Bone, Synovium, or the abnormal Biomechanics. This can be done by studying the Surrogate markers like the Cytokines (IL-1 alpha, TNF – alpha IL- 18 IL-6 levels in Synovial fluid), Chemokines – like Interferon gamma inducible protein -10 (CXCL – 10) , various Adipokines & Hormones.<sup>[10,11]</sup>

**Ethical Clearance ;** Taken from the Institutional Review Board before starting the study.

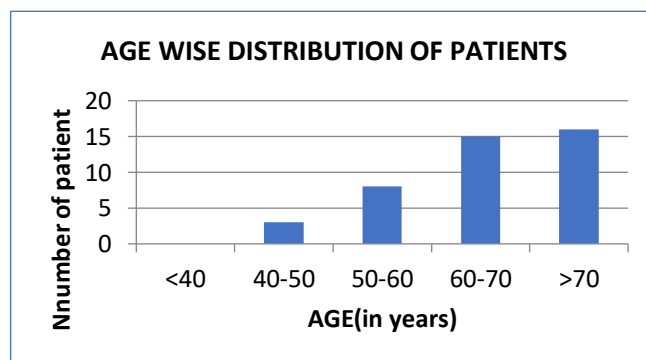
**Source of Funding ;**Self

**Conflict of Interest ;** None.

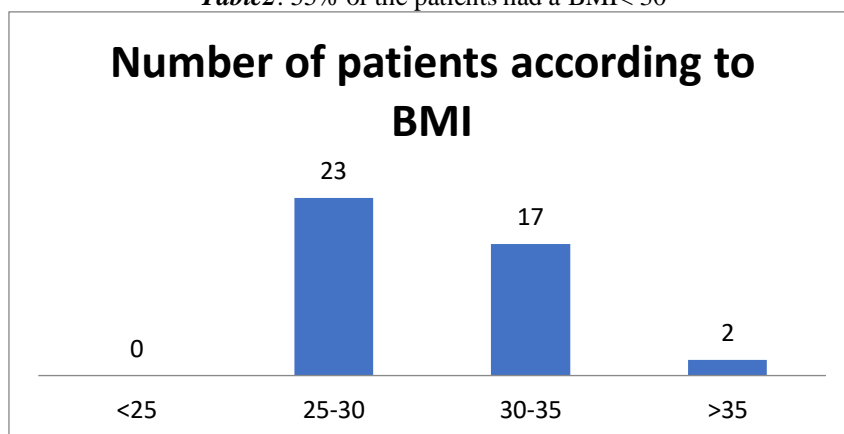
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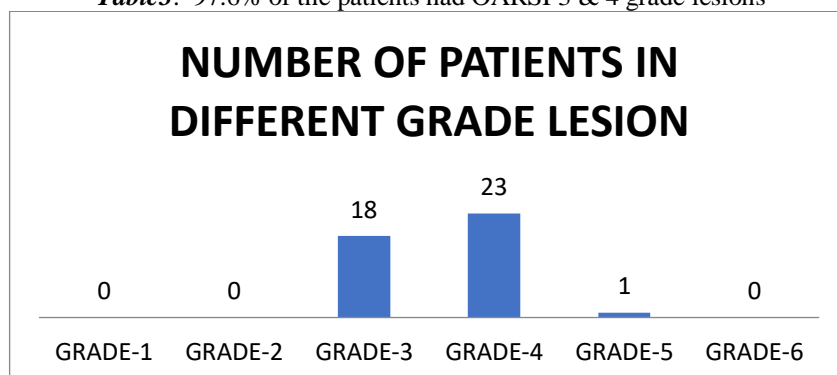
**Table 1:** The mean age of the patients in the study was 60 years



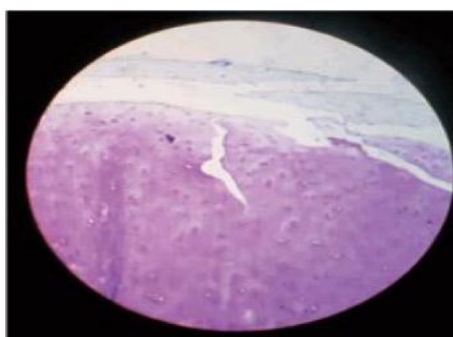
**Table2:** 55% of the patients had a BMI < 30



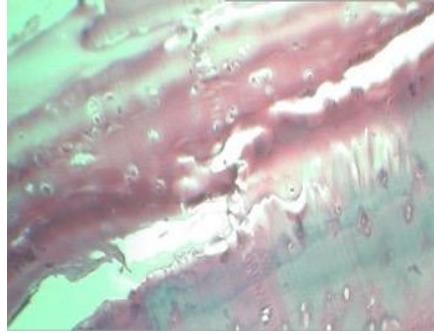
**Table3:** 97.6% of the patients had OARSI 3 & 4 grade lesions



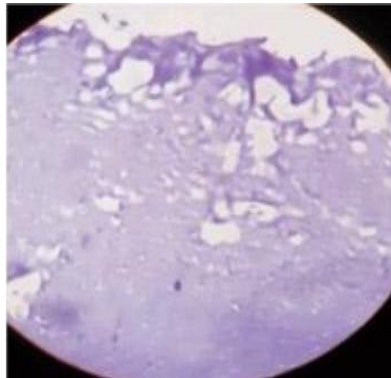
**Image 1a :** Conventional histology OARSI grade 3 cartilage damage (H&E, Light Microscopy 40X) Cartilage damage with presence of fissure extending almost 30% of the hyaline articular cartilage. The underlying bone has a normal histology



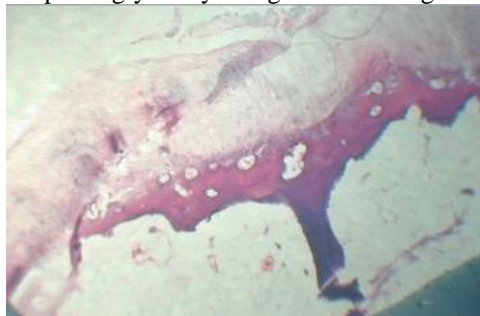
**Image 1b:** Alcian blue stain & polarized microscopy (40x) OARSI grade 3 cartilage damage. A fissure present in the upper layers with a loss of proteoglycan stain (light blue)The lower right shows a relatively normal cartilage



**Image 2a :** Conventional histology OARSIS grade 4 cartilage damage (H&E, Light Microscopy 10X) Presence of erosion & edema with mid zone excavation. (> 60%)



**Image2b :** Grade 4 cartilage damage (Polarised Microscopy 10X) Alcian Blue stain showing a loss of proteoglycan staining in the cartilage.



**Image 3 :** Conventional histology OARSIS grade 5 cartilage damage (H&E, Light Microscopy 10X) Cartilage denudation with an intact underlying bone surface

