Chondral Lesions of the Patella

Deepak Goyal[1]

Abstract

Background: The articular cartilage injuries of the patella are increasingly being reported, being more common in young population and are mostly associated with abnormal biomechanics. The abnormal biomechanics could be an instability, a maltracking or a patellofemoral overload. It is not uncommon to have a mixture of abnormal alignment and abnormal loading, making understanding of the patellofemoral biomechanics more difficult. Abnormal biomechanics put different types of biomechanical forces on the patella leading to the chondral damage. The patellar cartilage lesions usually show different patterns based on these different biomechanics. It is very important to understand the biomechanics of patella before treating the patellar cartilage lesion. A consideration to correct the abnormally aligned or loaded patella is an important step while treating a patellar chondral defect. The purpose of this article is to review the concepts behind occurrence of patellar chondral lesions and the biomechanics behind it, decision making with a brief overview of the treatment strategies

Keywords: Chondral Lesion, Patella, Maltracking, biomechanics

Introduction

The articular cartilage injuries of the patella are increasingly being reported. Aaron et al [1] reported 11% incidence of ICRS grade 3 or 4 chondral lesions in 993 consecutive arthroscopies, among which 23% were patellar defects. Isolated Outerbridge grade III patellar chondral defects were reported in more than 20% of patients younger than 40 years in a study by Curl et al [2]. In a systematic review of 11 studies that included 931 athletes, Flanigan et al [3] reported patellofemoral chondral defects in 37% of the athletes. In another systematic review of 9 studies that analyzed 771 patients who underwent autologous chondrocyte implantation (ACI), 18% lesions were at the patella and 19% at the trochlea [4]. Patellar chondral lesions are more common in young population and are mostly associated with abnormal biomechanics. The abnormal biomechanics could be an instability, a maltracking or a patellofemoral overload. It is very important to understand the biomechanics of patella before treating the patellar cartilage lesion. Keudell et al [5] reported that cartilage lesions over 0.9 cm^2 are biomechanically unstable, may degenerate at an unpredictable rate, ultimately leading to osteoarthritis. The purpose of this article is to review the concepts behind occurrence of patellar chondral lesions and the biomechanics behind it and to discuss the decision making process with a brief overview of the treatment strategies.

Patellar Chondral Lesion and the Biomechanics

Patellar biomechanics play a greater role in the health of the patellar cartilage. Any abnormal bio-mechanics will put abnormal loads on the patellar cartilage leading to a chondral damage. Understanding patellar biomechanics is a pre-requisite in planning the treatment of cartilage defects. The patellar biomechanics (Fig 1) can be broadly divided in three groups; (1) normally aligned and normally loaded, (Fig 2.a) (2) abnormally loaded (Fig 2.b) and (3) abnormally aligned (Fig 2.c). It is not uncommon to have a mixture of abnormal alignment and abnormal loading, making understanding of the patellofemoral biomechanics more difficult. A consideration to correct the abnormally aligned or loaded patella is an important step while treating a patellar chondral defect. Either abnormally aligned patella or abnormally loaded patella; both put different types of biomechanical forces on the patella leading to the chondral damage. The patellar cartilage lesions usually show different patterns based on the different biomechanics [6]. This chondral damage can be acute or can be chronic due to repetitive forces.

The abnormally aligned patella can lead to either an instability or a maltracking. (Fig 2.c) The common causes are trochlea dysplasia, patella alta, lateralised tibial tuberosity, valgus knee, anteversion

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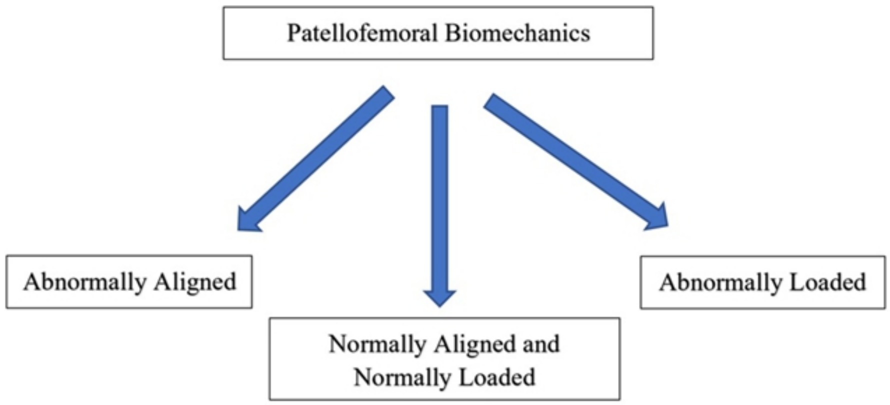


Figure 1: Classification of Patellofemoral Biomechanics: The patellar biomechanics can be broadly divided in to three groups; (1) abnormally aligned, (2) abnormally loaded and (3) normally aligned and normally loaded. It is not uncommon to have a mixture of abnormal alignment and abnormal loading, making understanding of the patellofemoral biomechanics more difficult.

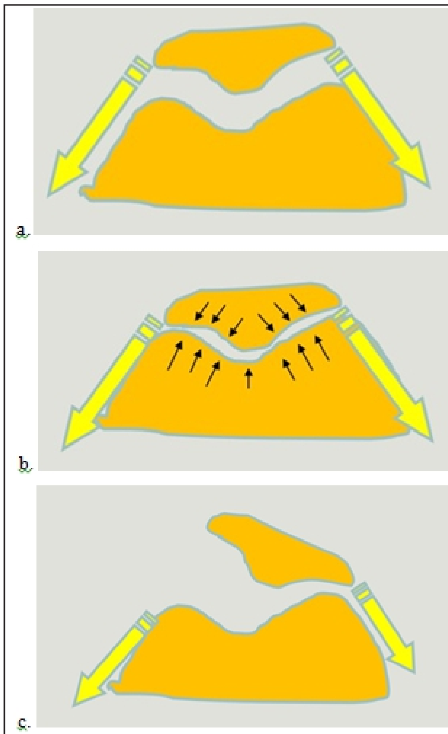


Figure 2: (a) A normal patellar excursion on the trochlear surface should not put any abnormal loads on the articular surfaces. (b) A tight patellofemoral/ extension mechanism abnormally loads the patella leading to a patellofemoral compression syndrome or an 'envelope effect'. This leads to constant rubbing of the part or whole of the patellar chondral surface against the trochlear surface, causing a regional or global chondral damage to the articular surfaces. (c) An abnormally aligned patella either creates a mal-tracking putting more loads on lateral patellofemoral joint or leads to an instability.

Figure 3: An abnormally aligned patella either creates a mal-tracking putting more loads on lateral patellofemoral joint or leads to an instability. However, presence of significant underlying bony anomalies increases chances of instability. The diagram shows presence of trochlea dysplasia leading to inefficient medial patellofemoral ligament and thereby causing patella instability.

of hip, and the MPFL (medial patellofemoral ligament) tear or MPFL insufficiency. These reasons, when more pronounced lead to patella instability. (Fig 3) Patella instability leads to lateral dislocation of the patella, where patella hits the lateral femoral condyle during the dislocation process and can cause chondral or osteochondral injury to the lateral part of the lateral femoral condyle. (Fig 4.a) The relocation process puts abnormal stress on the medial patellar facet that gets caught against the lateral condyle leading to a chondral or osteochondral fracture on the medial patellar facet or the distal patella apex. (Fig 4.b,c,d) This phenomenon is more commonly seen in the adolescent population. Patella instability cases that cause just the subluxation of the patella and not the complete dislocation of the patella, has the higher chances of lateral patellar facet rubbing against the lateral trochlear surface and that leads to a cartilage defect on the lateral patellar facet or the apex of the patella along with the cartilage damage on the lateral trochlear surface. The lateral patella maltracking also puts the similar loads on the lateral patella facet and lateral trochlear surface. While the medial restrains are compromised in patella instability, medial restrains are not compromised in maltracking.

The abnormally loaded patella leads to patellofemoral compression syndrome or an 'envelope effect'. (Fig 2.b) The most common causes are patellar tendinitis, quadriceps tendinitis, retinacular tightness, hoffa's fat pad syndrome, posterior capsular contracture, hamstrings tightness, iliotibial band tightness etc. Patella overload phenomenon causes patella to have higher compression forces against the trochlea. This leads to constant rubbing of the part or whole of the patellar chondral surface against the trochlear surface. Such cases develop

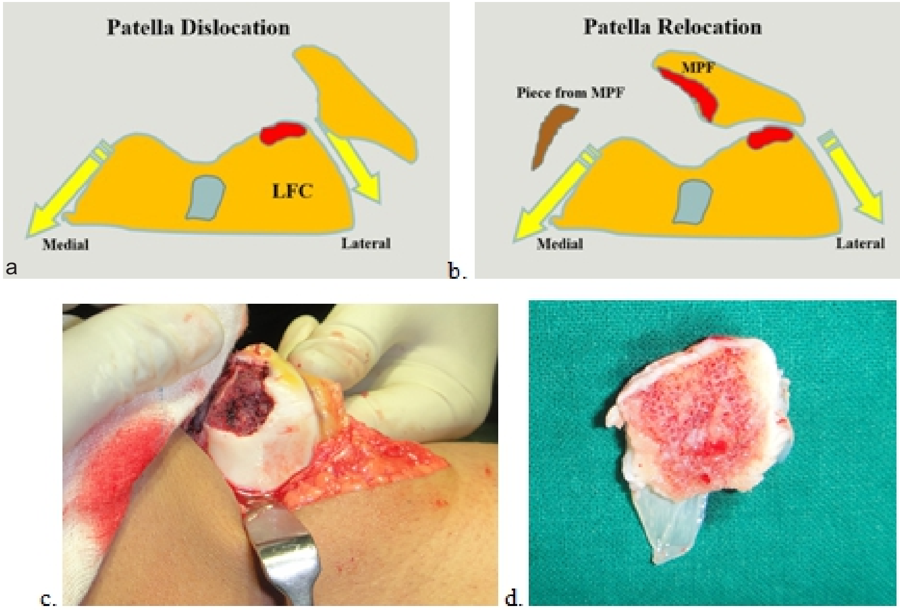


Figure 4: The common regions of the chondral damage during lateral dislocation of the patella. (a) During the lateral patellar dislocation process, patella hits the lateral femoral condyle and can cause chondral or osteochondral injury to the lateral part of the lateral femoral condyle. (b) During the relocation process, the medial patellar facet that gets caught against the lateral femoral condyle leading to a chondral or osteochondral fracture on the medial patellar facet or the distal patella apex. (c) A mini-arthrotomy in a male aged 15 years, who suffered lateral dislocation of patella, shows a chondral defect on the inferior part of medial patellar facet with (d) a separated osteochondral piece.

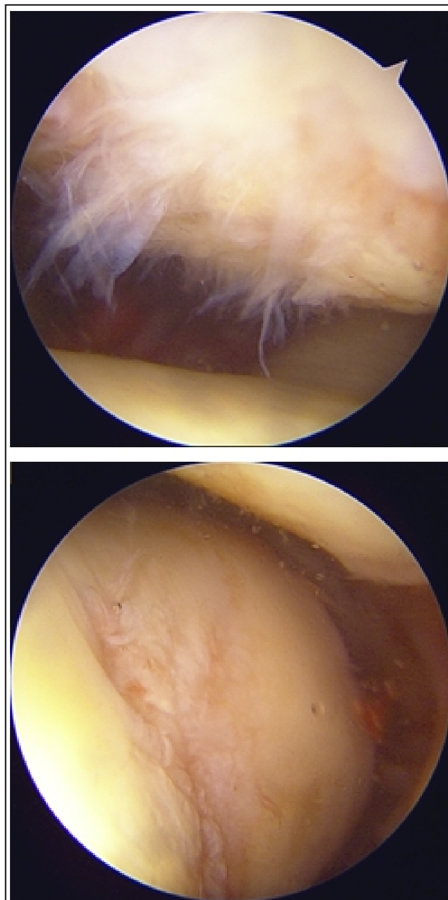


Figure 5: Patella overload phenomenon/ "tight envelope' effect leads to constant rubbing of the part or whole of the patellar chondral surface against the trochlear surface. (a) Such cases develop regional or global damage to the patellar cartilage surface as well as on (b) the trochlea.

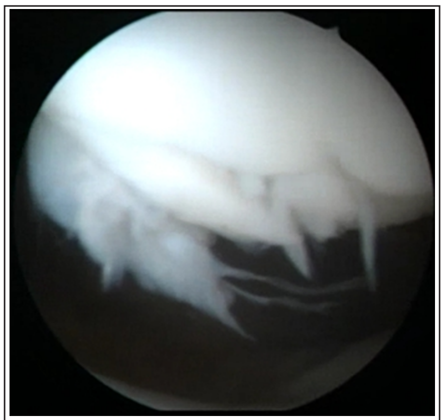


Figure 6: A traumatic chondral lesion on the patella due to direct hit leading to a burst fracture of the patellar chondral surface.

regional or global damage to the patellar cartilage surface. Occasionally, an area of complete cartilage loss in the center of the trochlea is seen on arthroscopy that have been caused by overloaded patella rubbing against the trochlear surface. (Fig 5) Instead, some cases may also show the bleb formation on the trochlear or patellar cartilage surface, that also indicates long standing overloading phenomenon.

Often, patella is neither abnormally loaded nor abnormally aligned, but still can have patellar cartilage lesions. The most common causes of such lesions are either traumatic or pathological. Traumatic causes are the shear forces leading to sliver of the chondral or osteochondral bone getting separated from the patella, or vertical direct impact force on the patella leading to burst cartilage damage at the apex of the patella. (Fig 6)

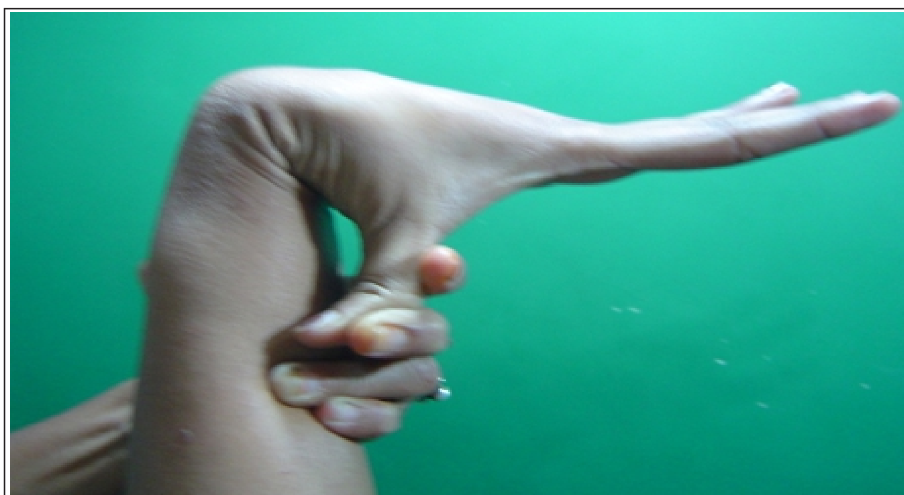


Figure 7: A positive thumb to forearm test indicating a generalized ligament laxity.

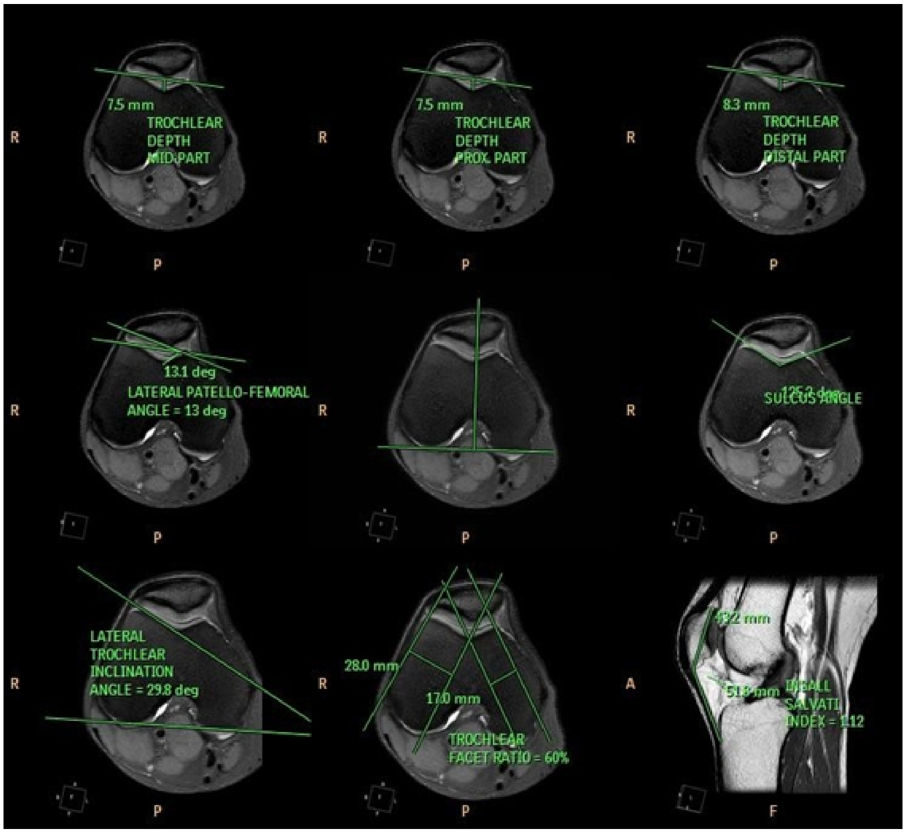


Figure 8: Patellofemoral indices: A detailed analysis of various patellofemoral indices like sulcus angle, patella tilt, lateral trochlear inclination, trochlear facet ratio, patella height measurements and tibial tuberosity trochlear groove (TTTG) measurements must be done to get an overall assessment of patellofemoral biomechanics.

Chondral Lesions

The patellar chondral lesions can be classified as per the size of the lesion, as per the depth of the lesion or as per the location of the lesion. Though sometimes confusing, these classification systems are crucial in decision making and treatment planning [7]. The Outerbridge classification [8] grades patellar chondral lesion depending on the size of the lesion and it is a macroscopic classification. The ICRS Classification [9] was developed to create an international uniformity in classifying the chondral lesions. The lesions in this system are largely classified depending on the depth of the lesion and this is an arthroscopic classification. The patellar chondral lesion can also be classified depending on the anatomic location of the lesion. The location of the lesion often gives an insight into the possible biomechanics behind the lesion and thus helps in strategizing the treatment. In a traumatic case, the lesions on the medial patellar facet can be due to the relocating patella, while on the lateral patella facet it can be due to constant rubbing of lateral patellar facet caused by chronic lateral subluxation. In an acute patellar dislocation event, a patellar chondral lesion will be present on either medial patellar facet or on inferomedial patellar cartilage surface. (Fig 4.c,d) In a chronic patellar lateral mal-tracking cases also, medal patellar facet can show a chondral lesion; but this is due to a long-standing disuse changes in the cartilage leading to chondromalacia. While chronic patellar maltracking will cause disuse chondromalacia on the medial patellar facet, the lesions on lateral patellar facet will be due to the overuse/ overloading. A global patella chondral changes can be a late squeal to the neglected cartilage damage, ending up in patellofemoral arthritis.

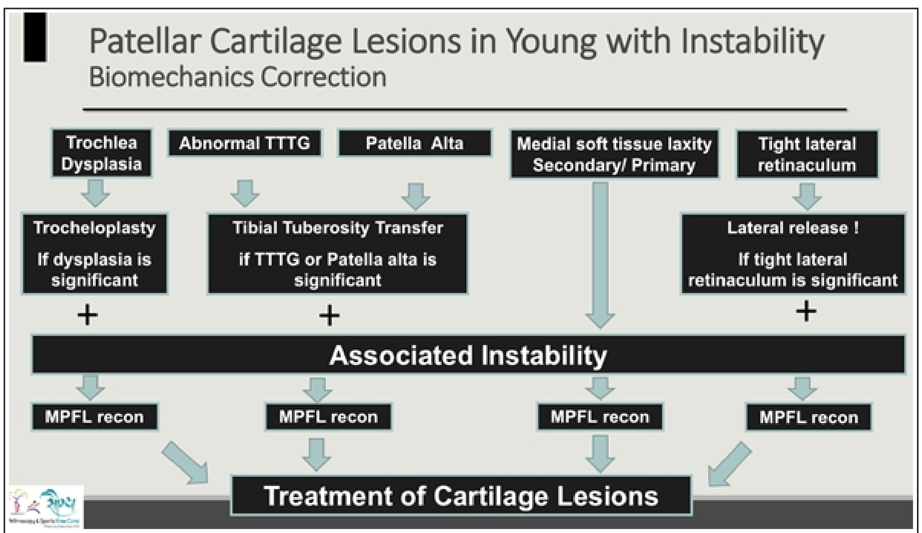


Figure 9: A treatment strategy flowchart to treat patella instability due to abnormal biomechanics. Note that a substantial stress is given to correct significantly abnormal biomechanics before a cartilage repair surgery is attempted.

Outerbridge Macroscopic Classification [8] (1961) for Chondromalacia Patellae

- Grade 1: Softening and swelling of the cartilage.
- Grade 2: Fragmentation and fissuring, less than ½ inch in diameter.
- Grade 3: Fragmentation and fissuring, greater than ½ inch in diameter.
- Grade 4: Erosion of cartilage down to the exposed subchondral bone.

International Cartilage Repair Society (ICRS) classification [9] (2003)

for Focal Chondral Lesions

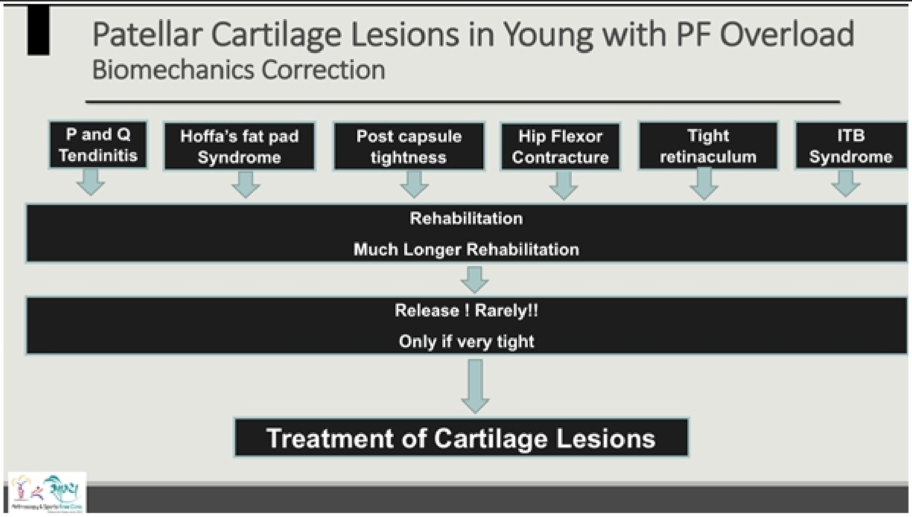


Figure 10: A treatment strategy flowchart to treat patella overload due to abnormal biomechanics. A fare chance must be given to rehabilitation before any surgical attempt is made.

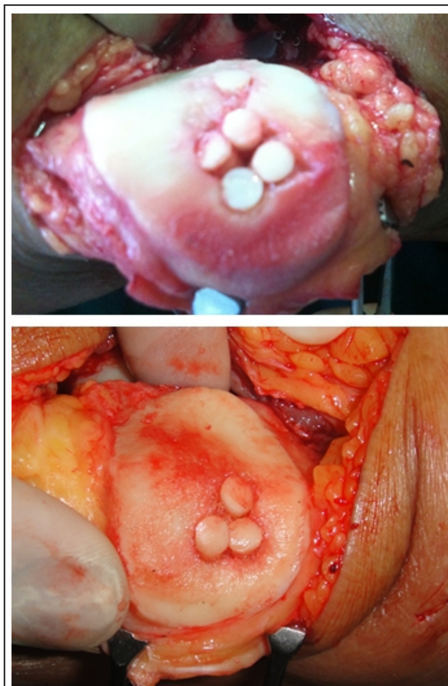


Figure 11: Osteochondral cylinder transfer technique (OCT) in patella can be challenging due to concavo-convex surface of the patella. (a) A large lesion treated with OCT can lead to patellar incongruency (b) while a small to midsized lesion can provide a congruous joint after an OCT procedure.

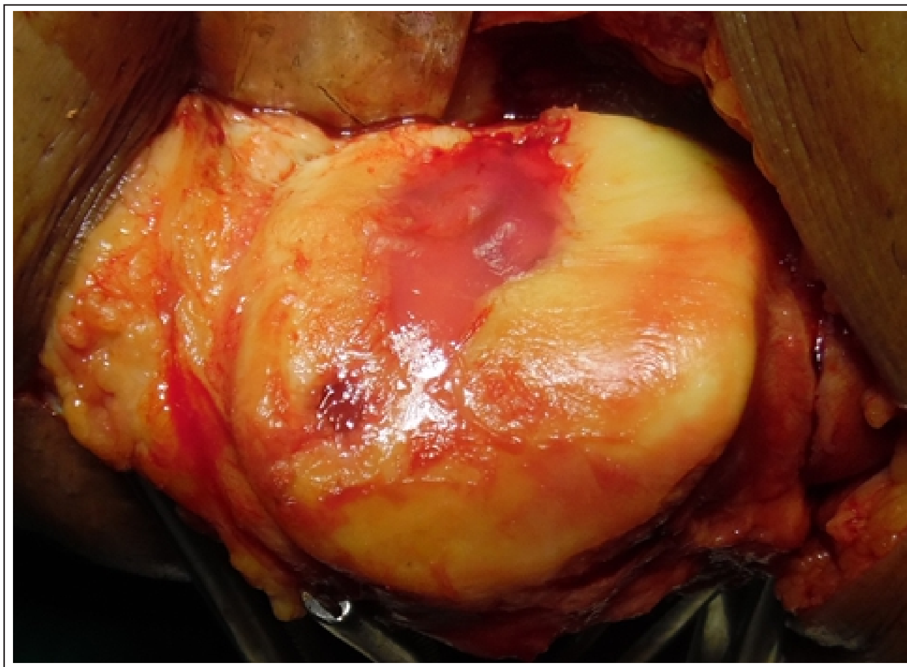


Figure 12: Newer generations of Autologous chondrocyte implantation (ACI) procedures provide excellent congruency after cartilage repair, even in large lesions as compared to osteochondral cylinder transfer techniques.

- Grade 0: Normal cartilage.
- Grade 1: Nearly normal (superficial fissures, lesions and cracks).
- Grade 1A: Superficial lesions or softening.
- Grade 1B: Superficial fissures and lacerations.
- Grade 2: Lesions extending down to <50% of cartilage depth.
- Grade 3: Severely abnormal (cartilage defects >50% of cartilage depth as well as down to the calcified layer of the cartilage).
- Grade 3A: A defect of more than 50% but not down to the calcified layer.
- Grade 3B: A defect down to the calcified layer.
- Grade 3C: A defect thru calcified layer but not thru the subchondral bone.
- Grade 3D: A defect with > 50% with blisters.
- Grade 4: Severely abnormal (Full-thickness cartilage loss with exposed subchondral bone).
- Grade 4A: Defect includes a superficial subchondral bone plate.
- Grade 4B: Defect includes deep subchondral bone.

Site based Classification of the Patellar Chondral Lesions

a. Patellar chondral lesion on the medial patellar facet
b. Patellar chondral lesion on the lateral patellar facet
c. Patellar chondral lesion on the apex
d. A global patellar chondral lesion

Decision Making

The first step in planning the treatment of patellar chondral lesions is to understand the biomechanics behind that lesion. A through clinical and radiological examination is required to understand; if patella is abnormally aligned, or abnormally loaded or is biomechanically normal.

Apprehension test and 'J' sign are

indicative of patella instability. A patella that can be dislocated laterally during knee extension or with knee extension and leg externally rotated; indicates either a MPFL tear or a stretched out MPFL. MPFL is torn in 94% of cases in patellofemoral dislocations. [10] MPFL is a medial checkrein that prevents lateral instability in extension and up to 30* of flexion. Beyond 30* of flexion, the patella stability is contributed by trochlear groove. Hence a presence of patella instability beyond 30* of flexion of the knee indicates associated trochlea dysplasia. The tight lateral structures can also contribute to lateral patella instability. If patella can be pushed half of its breath medially then lateral patellar retinaculum tightness can be ruled out. Presence of valgus knee indicates increased Q angle thereby suggesting increased lateral patellar force. In a standing position, in-toeing and/ or calcaneal eversion indicates increased anteversion of the hip. [11] A generalised ligament laxity (Fig 7) must be ruled out as it has a higher failure rate after a corrective surgery in patella instability case.

A dead lateral view of the knee joint is the most important radiological examination of the patellofemoral joint and gives insight to many possible diagnoses. (Table 1) The dead lateral view is the one, when the posterior margins of both the femoral condyles are absolutely overlapping each other. The important anatomical regions to examine during the dead lateral view are anterior cortex of the patella, articular surface of the patella, patellofemoral joint space, the trochlear articular surface lines and the patellar height. Any bony projection on the superior or inferior end of the anterior cortex of patella signifies the quadriceps tendon over-load or the patellar tendon overload respectively in the form of a bony spur. While a bony projection on the anterior cortex of patella indicates patellofemoral overload, a bony projection on the articular surface of patella indicates an osteophyte suggesting patellofemoral arthritis. Any incongruency in the articular surface of the patella indicates damage to the articular surface of the patella that can be a localised chondral defect in the early stages and can be a widespread arthritis in the late stages. A small area of incongruency in the patellar articular surface signifies subchondral (SC) damage due to an overlying patellar chondral lesion. Presence of SC cysts also indicates either a SC pathology and thereby an overlying patellar chondral lesion or a chondral lesion creating a SC cyst. Narrowing of patellofemoral joint space is again indicative of either an envelope effect or a patellofemoral arthritis. Presence of osteophytes in the trochlear surface signifies trochlear chronic cartilage damage leading to arthritic changes. The trochlear articular surface is represented by three lines. The trochlear articular surface lines represent medial and lateral trochlear margins, and the floor of the trochlea. The line representing the base or floor of the trochlea indicates the depth of the trochlear grove when compared to other two trochlear lines. In a classic paper describing trochlea dysplasia grading, DeJour H et al [12] gave an excellent description of the trochlear lines and classified trochlea dysplasia into four grades. (Table 1-#4,5) DeJour's classification is a very easy classification to diagnose various grades of trochlea dysplasia based on the findings of the dead lateral x-rays. [12, 13] Normally the trochlear floor line is seen as a prominent line and it should not cross the anterior cortex of the femur. When this line crosses the anterior cortex, it is known as a positive 'crossing sign' (type A) and it signifies a shallow trochlea. Presence of a supratrochlear spur indicates a flat trochlea (type B), while presence of double anterior cortex line signifies hypoplastic medial trochlea (type C). If the dead lateral x-ray shows both the double anterior cortex and the supratrochlear spur, then it indicates a cliff pattern formed by prominent lateral trochlea. (type D) The patella height is also a clue to the biomechanics and can be assessed using either Insall Salvati index or Caton-Deschamps index. A patella alta indicates a high riding patella suggesting a late engagement of patella in the trochlea and thereby increasing the chances of instability. A patella baja indicates a low riding patella suggesting an early engagement in the trochlea and thereby exerting more patellofemoral pressure on the trochlea leading to more chances of patellofemoral compression. A skyline view of the patella has a significance in assessment of trochlear depth, patella tilt and patella instability. An anteroposterior view of the knee is important to assess lateralisation of patella and to assess presence of a traction osteophyte in supero-lateral corner of patella, apart from assessment of tibiofemoral articulation and alignment.

MRI is an important radiological examination to confirm the clinical and x-ray-based findings. It also helps to understand the cartilage lesion in greater details like type of cartilage lesion, depth of a lesion, grade of lesions, status of surrounding cartilage and the status of the subchondral bone. Radiological angles measurements like patella height ratios, sulcus angle, trochlea depth, lateral trochlear inclination, TTTG ratio (tibial tuberosity to trochlear groove ratio) etc are another important aspect of the MRI examination. (Fig 8) Lateralisation of tibial tuberosity and thus effective lateral vector force can be determined by TTTG distance measurement on either MRI or CT.

Treatment Strategies

The first step to treat a patellar chondral lesion is to decide if there are any abnormal biomechanics and if there is a need for the biomechanical correction. Results of cartilage repair surgeries improve remarkably when simultaneous biomechanics correction has been carried out. [14] Often a small chondral lesion heals without any active intervention if the biomechanics are corrected. A chondral surgery is bound to fail, if the underlying significant biomechanics correction is not done either simultaneously or before the cartilage repair surgery. It is also necessary to understand the physiological limits of abnormal biomechanics and only significant abnormal biomechanics may require a correction. A surgeon must use his individual assessment to decide, as many abnormal biomechanics, though present are within physiological limits and hence may not require a simultaneous correction. For example, there is evidence that a pathologic trochlea correlates with the inferior results. [15] However, a type A trochlea dysplasia associated with recurrent patella dislocation may only need a MPFL reconstruction while documenting but not treating the type A trochlea dysplasia. The brief strategies of biomechanical corrections are discussed in Fig 9 and 10 for patella instability cases and patella overload cases, respectively. Both the strategies emphasize the significance of abnormal biomechanics but advocates biomechanical correction only if they are significant enough to affect the outcome.

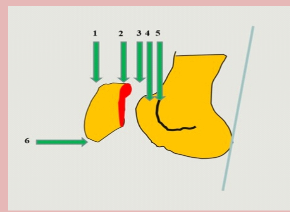
The cartilage surgery options are marrow stimulation techniques, osteochondral cylinder transfer technique, autologous chondrocyte implantations and bone marrow aspirate concentrate (BMAC). Each respective technique can be accessed in details from the literature. [16-22] It is generally very difficult to do microfracture on the patellar chondral under-surface as the required angle and forces to do the microfracture are not supported by the moving patella. However, abrasiochondroplasty is a good alternative to do the marrow stimulation to promote fibrocartilage formation. A marrow stimulation technique may be a good treatment of choice in a small degenerative lesion in elderly or in a small localised chondral lesion in young.

Osteochondral cylinder transfer (OCT) techniques are single stage techniques that promotes hyaline cartilage repair of the lesion, whereby osteochondral cylinders are transferred from the non-weight bearing trochlear margins to the load bearing chondral surface of the patella. The OCT is little more difficult to perform in patella as compared to femoral condyles because of the four reasons. The subchondral bone is much harder in the patella as compared to the condylar surface and hence it requires much higher forces to cut a cylinder at the patellar chondral surface. Secondly, the patellar chondral surface is concavo-convex making achievement of congruency more challenging as compared to femoral chondral surface. (Fig 11) Thirdly, most of the patellar chondral lesions are on apex which is a narrow summit. Hence there are higher chances of incongruency if OCT is chosen for the treatment of the chondral lesion on the apex of the patellar. Lastly, there are limited donor areas making treatment of large chondral lesions with OCT, nearly impossible. Though technically demanding, the decreasing failure rates of OCT in patellar chondral lesions are being reported. Nho et al [23] reported 67-100% cartilage fill at a mean 28.7 months on MRI, while Astur et al [24] reported full graft integration at 2 years follow up with a significant improvement in all the scores; both the series having lesion size from 1.65 to 2.5 cm^2.

Autologous chondrocyte implantation (ACI) has a known disadvantage of two stage surgery and a higher cost. However, its advantages outweigh its disadvantages because ACI provides hyaline (like) cartilage repair, has no size and shape restrictions and provides excellent congruency. [25] (Fig 12) There is enough evidence in literature providing long term good results of ACI. The ACI procedure has evolved over many generations from 1st generation to presently 3rd generations. The evolution of ACI generations has helped overcome many disadvantages of 1st and 2nd generation ACIs like periosteal hypertrophy, difficulty in creating watertight chondrogenic chamber, access to difficult to reach regions, monolayer culturing, and de-differentiation to fibroblasts etc. The results of patellar ACI had been historically reported as inferior to those of femoral ACI. However, most of the poor results can be attributed to either use of older generations (1st/ 2nd generation) of ACI or ignorance in simultaneous treatment of abnormal biomechanics. Gillogly and Arnold [14] reported only 4% failure of ACI at minimum 5 years follow up, while treating patellar cartilage defect along with anteromedialisation of tibial tuberosity. A level III studies by Ebert J R et al [26] compared matched groups of tibiofemoral MACI (2nd generation ACI) patients (n=94, medial; n=33, lateral) with patella--trochlear MACI patients (n=35, patella; n=32, trochlea) using KOOS, VAS and SF-36 clinical scores at 24 months. They concluded that patellofemoral group showed a statistically significant improvement similar to tibiofemoral group, when biomechanical correction was simultaneously performed for the patellar maltracking. [27]

BMAC is a mixture of the various marrow elements and MSC harvested from the bone marrow. The BMAC technology is getting popular because of easy harvest, easy processing methods and easy ethical clearances if not manipulated. [27] These bone marrow concentrate cells can either be injected into the joint, or culture expanded and used in conjunction with the scaffolds or can be used as an independent procedure. There are many preliminary studies that have shown better but also variable results with BMAC or BM-MSCs, and hence the future researches must find out the components that influence these results in the different preparations of BMAC.

Table 1: Clinical significance of bony changes seen on a dead lateral view of patellofemoral joint.



Arrow #	Anatomical landmark on a Dead Lateral View	Radiological Finding	Possible interpretations
# 1	Anterior Cortex of the Patella	A bony spur formation on the superior or inferior end	Either a quadriceps tendon overload or a patellar tendon overload respectively.
# 2	Articular Surface of the Patella	Osteophyte formation at the ends of the articular surface of the patella	Arthritic changes in the patellofemoral joint.
		Small area of incongruency on the articular surface of the patella	A localised area of cartilage damage reaching up to the subchondral (SC) bone.
		Small area of incongruency on the articular surface of the patella with sclerotic changes in SC bone	A localised area of cartilage damage reaching up to SC bone with attempt of SC bone attempt contain the lesion.
		Presence of SC cysts	A SC pathology or an overlying patellar chondral lesion leading to a SC cyst.
		Large area of incongruency in the articular surface of the patella	A diffuse area of the chondral damage or beginning of the arthritic changes.
# 3	Patellofemoral joint space	Joint space reduction	Tight patellofemoral compartment or 'envelope' effect.
		Incongruous patellar and trochlear surface.	Patellofemoral arthritis.
# 4 and 5	Trochlear cortex and groove	Crossing sign positive	Trochlea dysplasia type A- shallow trochlea
		Supratrochlear spur	Trochlea dysplasia type B- flat trochlea
		Double contour	Trochlea dysplasia type C- hypoplastic media trochlea
		Double contour and supratrochlear spur	Trochlea dysplasia type D- prominent lateral trochlea forming a cliff
# 6	Patella height	Patella baja	High chances of patellofemoral overload/ compression/ anterior knee pain
		Patella alta	High chances of patellofemoral instability

[28]

The best method to choose for the cartilage repair depends on many factors like the site of the lesion, the age of the patient, occupational demand of the patient, experience of the surgeon and also the logistics and availability of various procedures. A good conservative trial is must before attempting any cartilage repair surgery, as many cases respond well to conservative trials. For example, 'tight envelope'/ patellofemoral compression cases benefit more with a good set of stretching exercises, while they deteriorate more with a premature start of strengthening exercises.

A dedicated attempt to understand biomechanics thru detailed history and clinic-radiological examination is the primary step towards achieving a successful outcome. A customized rehab protocol must be attempted to treat such chondral lesions. A through thought to the biomechanics must be given before attempting a cartilage repair surgery, and if the abnormal biomechanics are significant contributors to the defect than those must be simultaneously treated.

Conclusions

The treatment of chondral lesions of patella depends on a thorough understanding of the abnormal bio-mechanics. Any significantly abnormal biomechanics must be treated first or simultaneously. The selection between various methods of cartilage repair depends on many factors like size of lesion, occupational demands, surgeon's experience and logistics. Often the corrected biomechanics lead to healing of the cartilage lesion, not requiring a definitive cartilage repair surgery.

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