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Gel Based Autologous Chondrocyte Implantation: The Surgical Technique

Deepak Goyal[1], Vishvas Modi[1]

Abstract

Autologous chondrocyte implantation (ACI) is one such technique that has the ability to provide a hyaline (like) repair of the localized cartilage lesions, even when they are of a big size. However, the procedure must be chosen very wisely because of its stringent indications and contraindications. Decision to do ACI procedure is very crucial and the surgeon must come to the decision after a detailed clinic-radiological examination. Gel based ACI is one such technique that allows a 3-dimensional distribution of the autologous cultured chondrocytes in a scaffold that is made of fibrin glue. The technique takes away the common complications that were associated with 1st and 2nd generation ACI; like graft hypertrophy, poor access to the lesion, membrane suturing, monolayer distribution etc. The purpose of this paper is to discuss the indications, contraindications, decision making and preoperative planning for the gel based autologous chondrocyte implantation technique in detail along with the surgical procedure, postoperative rehabilitation and the possible complications.

Keywords: Chondral lesions, Gel based, Autologous chondrocyte implantation, ACI, Cartilage repair, 3rd generation ACI

Introduction

The damaged cartilage tissues have a limited intrinsic capacity to repair itself. [1] The last two decades have seen inventions of multiple surgical techniques that can augment or stimulate the cartilage repair potential of the damaged tissues. [2,3] All these techniques have a primary aim of reducing pain and improving the functions of the affected joint, with an ultimate goal of regenerating the hyaline (like) cartilage that can provide structural, functional and compositional similarities to the native cartilage. [4,5]

Autologous chondrocyte implantation (ACI) is one such procedure where patient's own chondrocytes are harvested arthroscopically and then are cultured in the cartilage lab. At 4-6 weeks, these cultured chondrocytes are shipped back to the cartilage surgery facility and are implanted back either arthroscopically or through an arthrotomy procedure. ACI has now evolved from the 1st generation to the 3rd generation procedures. [3,6] 1st generation ACI involved the use of periosteum to create a chondrogenic chamber over the defect, in which the cultured chondrocytes were implanted. There were many issues with the use of periosteum like periosteum suturing, periosteal hypertrophy etc. The evolved 2nd generation techniques required the use of collagen membrane to create the chondrogenic chamber instead of the periosteum, over the cartilage defect. Though the 2nd generation technique solved some of the problems associated with the 1st generation ACI; it was still difficult to suture collagen membrane at the defect for the less accessible locations of the lesion. The 3rd generation ACI involved the use of membrane seeded cultured chondrocytes that was done in the laboratory itself and then transported to the operating room for a direct implantation without the need for suturing. [7,8] The 3rd generation ACI technique further evolved from a monolayer distribution of the cells to the 3-dimensional distributions of the cells by using 3-dimensional scaffolds. [9,10] One of the 3-dimensional scaffold technique is gel based autologous chondrocyte implantation. The purpose of this paper is to discuss the indications, contraindications, decision making, surgical techniques, post-operative rehabilitation and the possible complications associated with the gel based ACI.

Indications & Contraindications

Indications

Autologous chondrocyte implantation is the treatment of choice when all of the below conditions are met with in a particular case. [6,11,12]

1. A symptomatic patient.
2. Age from the teenage to the middle age (14-55 years approximately). A localised lesion with healthy margins in a physiologically active patient can be an indication even at a little higher age. In the same way, smaller age is not an absolute contraindication.
3. A full thickness cartilage defect with an ICRS grade III or IV as per ICRS classification / or osteochondritis dissecans (OCD) stage III or IV as per ICRS-OCD classification.
4. The defect size should preferably be more than 2 cm^2, as the smaller size lesions can be treated with comparable results using the less

[1] Saumya Arthroscopy & Sports Knee Clinic, Ahmedabad, India.

Address of Correspondence:
Dr (Prof) Deepak Goyal
Saumya Arthroscopy & Sports Knee Clinic, Ahmedabad, India.
Email: deepak@knee.in


Dr. (Prof) Deepak Goyal


Dr. Vishvas Modi

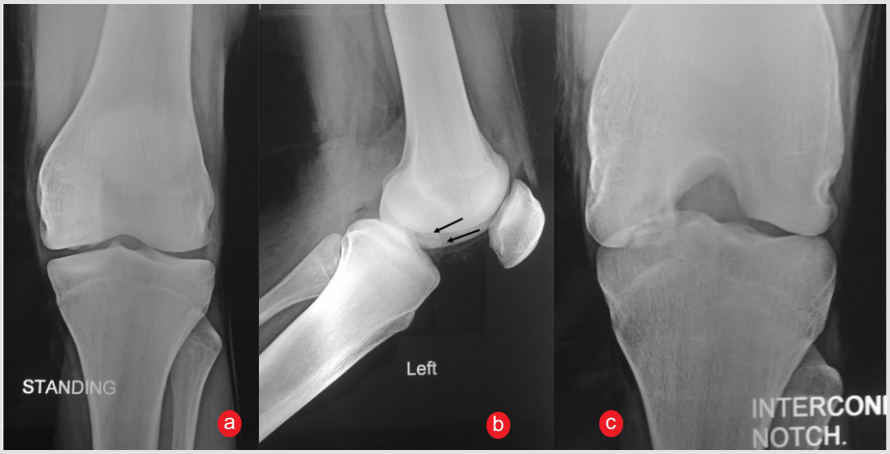

Figure 1: a) An anteroposteior view x-ray of 32 years old male patient showing minimum incongruency of the medial femoral condyle on the left side, following complaints of insidious origin pain in left knee for a duration of 6 months. b) a lateral view x-ray of the same patient showing multiple loose bodies raising suspicion of the osteochondritis dissecans. c) a Schuss view x-ray of the same knee confirms the diagnosis as the lesion is more posterior in the medial femoral condyle.

invasive single stage techniques. Although there is no higher size limit, the bigger lesions have a relatively poor outcome as compared to the mid-size lesions.
5. A purely chondral lesion, or an osteochondral lesion with a reconstructed subchondral (SC) bone.
6. In the knee joint, the defect can be localised to femoral condyles, patella, trochlea or tibial articular surfaces. However, the best results are obtained for the lesions at the femoral condyles.
7. The joint must have normal biomechanics or corrected biomechanics.
8. A cooperative patient for the post-operative rehabilitation program.

Contraindications

Autologous chondrocyte implantation should not be attempted if any of the following conditions are present in a particular case. [6,11,12,13]
1. Altered biomechanics or untreated abnormal biomechanics of the joint e.g. Tibia vara.
2. Degenerative joint
3. Inflammatory joint disease e.g. Rheumatoid arthritis
4. Septic joint disease e.g. infective arthritis
5. Metabolic disorders e.g. uric acid crystallopathy
6. Smokers
7. Obesity (BMI>30) , a relative contraindication if all the other conditions are ideal
8. Non-cooperative patient
9. Age > 55 years, is a relative contraindication. ACI can be performed if the patient is physiologically active with a stable and healthy cartilage margins in a single localised chondral defect.

Preoperative Evaluation

Clinical

A detailed clinical history is of a high significance. Age, the onset and duration of symptoms, history of injury or an insidious origin, type of pain and swelling, presence of catching/ locking/ instability related symptoms, h/o previous surgery, involvement of other joints, etc are important to clinch the exact diagnosis as well as to judge the prognosis of the ACI technique. Patients with BMI > 30 kg/ m2 may show worse outcome. [13]

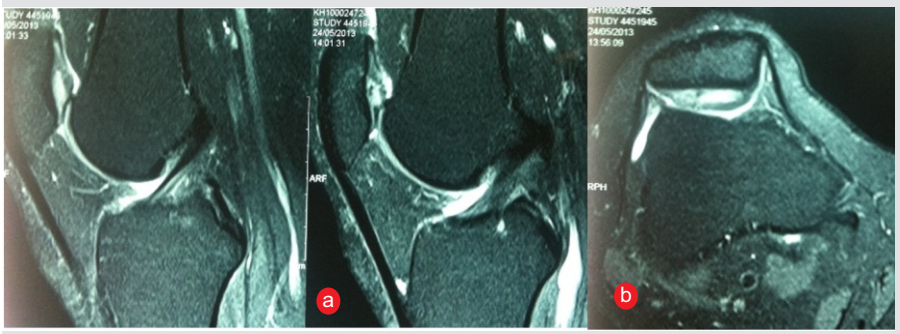

Figure 2: a) T2 weighted sagittal MRI images of 39 years old female suffering from right knee pain for 1 year, of insidious origin. MRI shows patellar chondral defect with a fluid interface between the cartilage and the patellar subchondral bone. There are areas of cartilage separation seen in another sagittal image as well as axial image (b).

ACI, like the other cartilage repair techniques gives better results at a younger age compared to the senior age. [3,14,15] ACI performed in injury cases or OCD cases gives better results compared to the ACI done in the cartilage lesions arising from other reasons like osteonecrosis. Patients undergoing ACI with short duration of history (<1 year) following trauma gives a better clinical score as compared to a patient with a longer history of trauma. [16] Similarly, patients treated with ACI for OCD produces better clinical results, more so if the duration of the symptoms is of a lesser period. [16] Symptoms arising due to a cartilage lesion and its duration are also equally important. A longer duration of the symptoms (>3 years) gave poor functional outcome suggesting that an earlier cartilage repair is better. [17] The history of a prior cartilage surgery is also important as it might significantly deteriorate the prospects of a secondary ACI surgery. [11]

The type of pain and swelling gives a clue about its source. Pain arising on weight bearing or on loading activities is more likely to originate from the cartilage lesions at the tibiofemoral joint, while pain on using stairs or on standing from a sitting position is more likely to originate from the patellofemoral region. [18] Similarly, the area of tenderness and swelling would also match with the location of the lesion. Associated symptoms of catching/ locking or instability must be looked-for proactively by the surgeon. These symptoms may be coming from a meniscal tear or a ligamentous instability. Lastly, particular attention must be given to rule out any abnormal biomechanics; as a cartilage repair done without correction of the biomechanics is bound to fail from the day one. A cartilage lesion of degenerative or inflammatory origin must be excluded to avoid failures.

The clinical examination should include a detailed examination of the tibiofemoral as well as the patellofemoral joint. Patella examination should be done for an evidence of mal-tracking or instability. McMurry tests and ligament evaluation tests must be carried

out to rule out concomitant injuries like a meniscus tear or a ligamentous instability. Any tibiofemoral or patellofemoral biomechanical abnormality like tibia-vara must also be ruled out. If any of the concomitant pathology is detected, then it must be treated before the ACI procedure is carried out. [18]

Imaging

X-rays

Standing AP view, dead lateral view and schuss views are the first x-ray (fig. 1) that should be ordered. A patellar skyline view is also recommended if a patellofemoral pathology is suspected. [18,19,20] These basic x-rays allow an assessment of tibiofemoral and patellofemoral alignments, joint space, articular congruency, subchondral bone cysts, and presence of any osteochondral defect or a pathological condition. OCD is usually seen as a well-circumscribed lucent defect in the subchondral bone that may or may not have a similar bone density as the surrounding bone. [21] Osteonecrosis may have many radiological appearances like the reverse moon sign, an area of sclerotic subchondral bone in a ray fashion, a flattening of the condylar surface or the presence of lucencies in the subchondral bone. [22,23]

Osteoarthritis will be evident by a decreased joint space, presence of osteophytes, subchondral bone plate sclerosis and the presence of subchondral bone cysts. [24,25,26] A long limb alignment x-ray is a must while suspecting a tibio-femoral cartilage lesion. It gives an important clue, if biomechanical axis needs to be corrected before a cartilage repair is attempted. [27]

MRI/ CT

The role of MRI is not only to identify, quantify and document a cartilage lesion/s, but also to diagnose the concomitant pathologies like a meniscus tear, ligament tear and the involvement of the subchondral bone. Another important role is to identify the abnormal patella-trochlear biomechanics, mainly in the case of a patellofemoral joint involvement. [28]

The cartilage lesions should be assessed for the type of lesion, grade of the lesion (for example ICRS classification), depth of the lesion, surrounding cartilage status etc. (fig 2) The presence of subchondral bone oedema, oedema pattern, subchondral bone cysts etc indicates either an overload pattern or a vascular insult. Both the conditions must be diagnosed carefully and treated either before or concomitant to the ACI procedure.

In case of OCD, a crescentic or ovoid focus of the SC signal abnormality is important in the early cases. The important point to keep in mind is whether the OCD fragment is unstable or stable, as it is an important decision-making factor for the treatment plan. An unstable fragment is seen with a high signal intensity on T2W images between the OC fragment and the underlying bone. [29] Hypointense area on T1 weighted images is seen in the early stages in the osteonecrosis cases. An hypointense area appearing just below the SC bone on T1 and T2 weighted images may be seen. A few cases show a ray like appearance in the T1 and T2 weighted images indicating a loss of vascularity in one particular vessel affecting a cone shaped area of the SC bone. In the late stages, diffuse area of bone marrow oedema is highly suggestive of osteonecrosis. [30,31,32,33]

CT scans are more important when there is a major loss of the subchondral bone. A detailed CT scan study helps in planning the osseous reconstruction of the damage a subchondral bone.

Preoperative and intraoperative planning

Counselling

A motivated and well-informed patient is the right choice for the ACI procedure. Surgeon should spend enough time with the patient and the relatives explaining about the cause and type of the cartilage defect, presence or absence of associated concomitant pathologies, the outcome of untreated lesions and expected prognosis of the treated lesions. The surgeon should be aware of any animal product that is being used in the ACI implant and must take the informed consent for the same, in order to respect the religious and cultural sentiments of the patient. [34]

Preoperative Planning

The most important and the first step in pre-operative planning is to identify the abnormal biomechanics and to rule out the systemic, inflammatory and the immunological diseases. A detailed clinical examination, imaging and laboratory investigations performed at the evaluation stage can help the surgeon reach the primary objectives of the planning.

Next step is to plan a strategy to correct the biomechanics if abnormal or treat the concomitant lesions. The cartilage biopsy should be combined with the biomechanics correction surgery/ concomitant surgery. [35] This step is important as this will give the surgeon an opportunity to allow the postoperative management and rehabilitation of the corrective bio-mechanics surgery, while the chondrocytes are being cultured in the cartilage lab. Between 4-6 weeks, while the cultured chondrocytes are ready for implantation; patient has completed the major part of the rehab program that is required after the biomechanics correction/ concomitant surgery. For example, a patient requiring a valgus producing high tibial osteotomy along with the ACI for the medial femoral condyle lesion can undergo a cartilage biopsy and the corrective osteotomy as the first stage surgery. In 4-6 weeks, most of the postoperative rehabilitation that is required for the osteotomy will be complete and then, an exclusive ACI procedure can be easily carried out without worrying for the postoperative management of the biomechanical correction surgery. If the biomechanics correction or concomitant surgery is not required, then the surgeon should choose to do an isolated arthroscopic harvesting of the cartilage biopsy.

The final step is to plan; how to access the lesion with a minimum invasion and how to prepare the lesion. While some of the lesions can be implanted with ACI using an arthroscopy procedure, a majority of the lesions require a mini-arthrotomy or a full-fledged arthrotomy. As the gel based ACI is in semi-liquid form, a gravity neutral floor of the lesion is a must. A lesion on the tibial plateau can be implanted with dry arthroscopy, where the surface of the tibial cartilage lesion is parallel to the ground. Some of the cases of the trochlea or the femoral condyles can also be treated in a similar fashion, while the lesion is kept gravity neutral by doing a combination of flexion/ extension at the hip and knee. However, for better access and better implantation of the gel based ACI, a mini-arthrotomy is advised. A patellar lesion by default should be treated by everting the patella after a mini-parapatellar medial arthrotomy.

Surgical Technique

Autologous chondrocyte implantation is a

Figure 3: A hexagonal cartilage biopsy taken from the lateral margin of the trochlea. Cartilage biopsy piece is put in the carrying media for transport to the cartilage lab. A small piece of underlying bone is also taken to ensure that full thickness of the cartilage is harvested for the biopsy

two-stage procedure with involvement of a GMP certified cartilage lab for the culture of the chondrocytes after the 1st stage procedure.

1st stage of ACI

The most important steps in the 1st stage is to reconfirm the clinical findings, to treat concomitant injuries/ pathologies/ biomechanics and to take a cartilage biopsy for the chondrocytes culture. [6] A cartilage damage is evaluated in detail as per ICRS classification or as per Outerbridge classification. A gel based ACI requires a harvesting of a hexagonal osteochondral cylinder where the bony part is just a few millimetres thick. (fig 3) This is done to ensure that full thickness cartilage is harvested for the biopsy. The most preferred sites are non-weight bearing area of either the medial trochlea or the lateral trochlea above the sulcus terminalis. The best way to ensure this is to put the knee in hyper-extension, so that all the weight bearing areas of the femoral condyles are covered by the tibial articular surface. The harvested biopsy material is sent to the cartilage lab for a culture.

Cartilage Lab

The donor chondral tissue undergoes an enzymatic digestion, cleaning and then cell expansion in a monolayer culture at a GMP certified cartilage lab. The donor chondrocytes are cultured in-vitro for 4- 6 weeks. For each 1 cm^2 size cartilage defect size, approximately 1 million chondrocytes are cultured. When the culture process is nearly complete, the cartilage lab informs the operating surgeon about the final date of the delivery of the cultured chondrocytes. The final cartilage lab report of the chondrocytes culture must state the cell count, cell viability, cell characterisation and the cell morphology of the cultured cells. In additions, the presence of any pathogens and endotoxins must be ruled out and supported by the cartilage lab report.

2nd stage of ACI

Generally, this is an open procedure with a mini-arthrotomy. However, occasionally an experienced cartilage surgeon may perform arthroscopic implantation of the cultured chondrocytes at a selective site; for example, the tibial plateau.

Surgical approach: A mini medial parapatellar approach parallel to the patellar tendon for the medial femoral condyle lesions and a mini lateral parapatellar approach parallel to the patellar tendon for the lateral femoral condyles lesions is advised. For the patellofemoral cartilage lesions, a limited medial parapatellar approach is advised starting form the inferior end of the patella, circulating across the medial patellar margin and ending near the superior end of the patella. (fig 4) The surgical approaches might be extended as per the requirement during the procedure.

Lesion Preparation: The cartilage lesion is exposed completely by properly placing the retractors around the soft tissues. The base of the cartilage lesion is cleared of all the fibrous tissues and fibrocartilage formation till the raw subchondral bone plate is achieved throughout the base of the lesion. Any internal osteophyte or the subchondral bone thickening should be removed at this stage and should be brought at the level of the surrounding subchondral bone plate. Any subchondral bone cyst is also dealt with at this stage by cleaning the cyst and filling it with an autogenous bone graft, thereby converting the procedure to the overlay ACI technique. [36]

The margins of the cartilage lesion are prepared using a 15 # blade and a sharp ring curette. (Fig 5) First, the knife is used to put an oblique cut on the periphery of the cartilage lesion in such a way that the margins are bevelled shaped with more tissue removed from the depth than on the surface. This is important so that the gel based ACI implant gets an inherent stability from the overhanging margins of the surrounding cartilage. Then a sharp ring curette or a periosteum elevator is used to remove the remaining irregular and damaged cartilage. This is ensured by curetting the tissues from

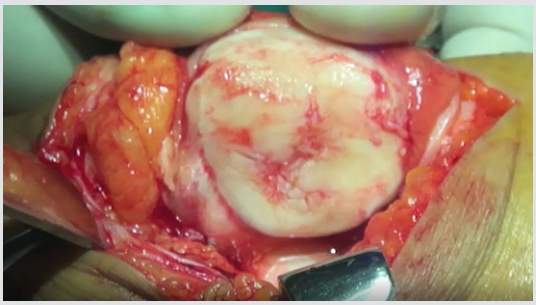

Figure 4: A medial parapatellar arthrotomy starting from inferior pole of patella, circulating around the medial parapatellar margins and ending near the superior pole of the patella. A gradual eversion of the patella is done to expose the patellar chondral surface.

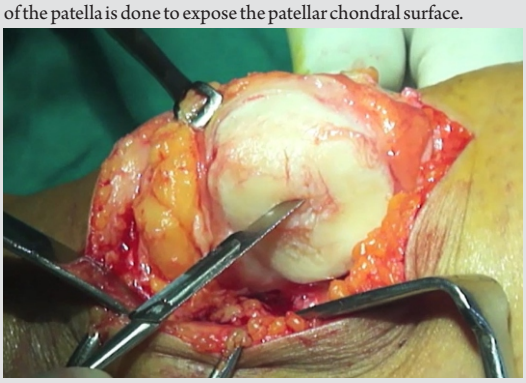

Figure 5: A 15 # blade is used to put an oblique cut on the periphery of the cartilage lesion in such a way that the margins are bevelled shape. This ensures that more tissues is removed from the depth than on the surface. This step provides inherent stability to the gel based autologous chondrocyte implant by the overhanging margins.

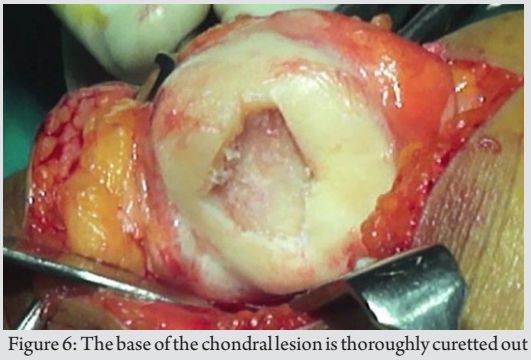

Figure 6: The base of the chondral lesion is thoroughly curetted out to remove all the fibrocartilage and fibrous tissue till a clean subchondral bone surface is achieved.

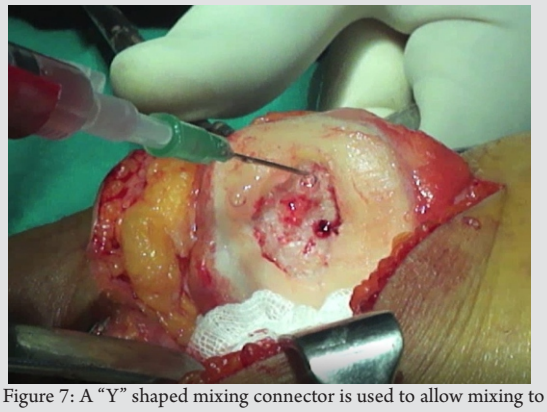

Figure 7: A "Y" shaped mixing connector is used to allow mixing to fluid coming out of two different syringes. First syringe contains 1 ml fibrinogen, while another syringe contains 0.1 ml thrombin and 0.9 ml of cultured chondrocytes. A drop by drop implantation of the mixture is done so that the fluid doesn't flow out.

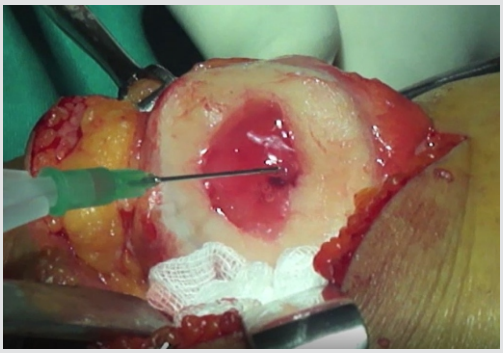

Figure 8: A layer by layer implantation of the gel based autologous chondrocyte cells is done to create a 3-diemensional scaffold, made up of fibrin and the cultured chondrocytes.

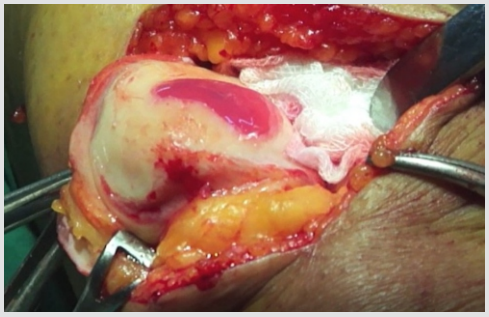

Figure 9: The gel based autologous chondrocyte implant is kept minimally proud. The contour of the host bone is taken into consideration so that repaired cartilage is congruous with the joint.

the previously created bevelled margins towards the centre of the lesion. This also ensures that only the healthy cartilage remains all around the prepared cartilage defect, (fig 6) which is important for a good integration of the regenerating cartilage. The size of the prepared defect is then measured for the documentation purpose and for the follow up assessment. A few tiny holes can be added on the base of the lesion, not penetrating thru the subchondral bone plate, to assist the anchoring of the ACI implant with the base of the lesion.

Implantation of the autologous chondrocytes: Two one ml syringes are used with a "Y" mixing connector. First syringe contains 1 ml fibrinogen while the second syringe contains 0.9 ml of cultured chondrocytes and 0.1 ml of thrombin. Each drop of the syringe contains a mix of chondrocytes and the thrombin-fibrinogen mixture that forms fibrin. (fig 7) Thus a 3-dimensional, layer by layer scaffold, is created on the cartilage defect that gets inherently inhabited by the cultured chondrocytes, ultimately forming a multi-layered ACI implant. (fig 8) One must be careful that the base of the defect remains gravity neutral in order to keep drops of the gel contained inside the defect; otherwise the gel may flow out. Any gel flowing out of the defect should be wiped out repeatedly with the help of dry patties. The gel gets solidified in 8-10 minutes. [37]

A final inspection is made at the end to see if all the implanted ACI graft is contained inside the defect with no empty spaces or bubbles. A minor proud of the graft beyond the surrounding surface of the cartilage defect is advisable but it should be a very minimum. (Fig 9) A gentle flexion extension ROM is carried out 3-5 times and then a reinspection is done to cross-check if the implant is dislodged from the defect or not. [37] A gentle wash is given, and a closure is done in layers.

Postoperative Management and Rehabilitation

Management of pain and inflammation, while protecting the ACI graft; are the most important tasks in the immediate postoperative period. Ice application, compression bandage and elevation to the limb should be advised.

The rehabilitation program following ACI is vital for the successful long-term outcome of the patient. [38,39,40] The concept of a slow, gradual maturation of the repair tissue is crucial to understand the rehabilitation program. [38,39,40] Premature overload of the repair tissue will increase the likelihood of failure. [18] The critical elements during the initial phase of the rehabilitation are full range of motion, protection of the graft from the mechanical overload, and strengthening exercises to allow a functional gait. Early controlled ROM and weight bearing are also necessary to stimulate the cellular orientation and chondrocyte development. [18]

A full-length leg brace is important to avoid any undue shear force to act on the knee. Once pain subsides, the patient is encouraged to walk. If the ACI is done in the tibiofemoral region, then a non-weight bearing walking with the support of crutches is advocated. However, if the ACI is done in the patellofemoral region, then a partial weight bearing is allowed with crutches; while the limb is protected in full length leg brace locked in full extension. Smaller well contained defect cases may be allowed early weight bearing, as early as 1- 2 weeks. However, large or deep lesions cases are advised to start partial weight bearing at 2-4 weeks depending on the surgeon's judgement of the likely forces working on the defect. A ROM brace with the dial lock function may be given to the patient after 2-3 weeks, while walking. An approximate increase in the range of ROM brace by 40° per week is recommended till the patient gets the full range by 6 weeks. All types of braces should be discontinued at 6 weeks if the quadriceps have good strength.

Continuous passive motion machine (CPM) is started 6 to 12 hours after surgery. The CPM is used for 6- 8 hours per day and is recommended for up to 6 to 8 weeks. In the beginning, CPM range should be carefully monitored, and it should not put undue stress on the soft tissues leading to a swelling at the surgical site. While the CPM is advocated to signal cells to regenerate into hyaline (like) cartilage, active movements are required to gain full flexion and extension. The surgeon must be cautious to encourage active and active assisted flexion and range of movements, so that the soft tissue adhesions don't take place. The physiotherapist must target to achieve a full range by 3 weeks, irrespective of the site of the lesion; unless demanded by the surgeon due to case-specific reasons. It must be emphasized that CPM and active movements, both are essential and have different roles to play. Emphasis is also put on restoring the quadriceps strength initially and then progressed to maximize the strength of the entire lower extremity. Addition of further exercises should be based upon the size, location, and amount of containment of the lesion by the normal surrounding cartilage. It may take up to 6 months for the graft site to become firm and up to 9 months to become as durable as the surrounding healthy articular cartilage. [41,42] Full maturation of the repair tissue may take from 12-24 months [41] or beyond. Thus, low impact activities, such as swimming, biking, golfing, and skating can be initiated by 5 to 6 months and progressed to moderate-impact activities, such as jogging, from 7 to 9 months. The high impact activities can be started beyond one year.

Outcomes

Peterson et al (2010) published long term results of 1st generation ACI. [43] The mean age of the patients at the time of ACI was 33.3 years and mean follow-up was 12.8 years, with mean lesion size of 7 cm^2 per patient. 224/ 341 patients responded to survey and 92% patient said that they would go for ACI

again, if a similar situation arises.
Goyal et al (2014) did a systematic review of 2nd and 3rd generation ACI over 1st generation ACI using level I and II studies. [14] The level II evidence till 2 years of follow-up suggested better results of the 2nd generation ACI in young patients with medium size defects as compared to the 1st generation ACI. 3rd generation ACI was also found to give comparable results with minimum complications till 2 years follow up.
Pareek et al (2016) did a systematic review of literature using 9 studies. They reported success ratio of 82% in 771 cases with a mean lesion size of 5.9 cm^2 ($\pm$1.6 cm^2) and a mean follow-up of 11.4 years. [44] All the 9 studies that were included in the systematic review used various generations of ACI.
MK Kim et al (2010) [45] had done fibrin ACI for deep defects of the femoral condyle in 30 patients and all the patients achieved clinical and functional improvement at up to 24 months. Arthroscopic assessments performed 12 months post operatively produced nearly normal (Grade II) International Cartilage Repair Society score in 8 of the 10 patients and the mean score of Henderson classification (MRI evaluation) significantly improved from 14.4 to 7 (p=0.001) with no graft associated complications noted.
NY Choi et al (2010) [37] analysed data of 98 patients operated with gel based ACI, with mean age of 43.7 years and the mean lesion size of 5.23 cm^2 ($\pm$2.70 cm^2) at the mean follow-up of 24.35 months (range 13-52 months). They observed an improvement of tKSS-A (telephone Knee Society Score-A) from 43.52 to 89.71 and an improvement on the tKSS-B (telephone Knee Society Score-B) from 50.66 to 89.38. The total improvement was from 94.18 to 179.10 ($P < 0.05$).

Complications

A per-operative complication like dislodging of the implanted ACI graft can occur while doing the check ROM. If extra chondrocytes are available, then reimplantation of the cultured cells should be done. However, if there are no spare cells, then the dislodged ACI graft can be sutured with the surrounding cartilage using 5-0 vicryl.
The immediate postoperative complications can be the same as that of any post-arthrotomy procedure like pain, inflammation or swelling etc. A proper postoperative management described above should take care of it.
Late complications like hypertrophy of the graft were common after the periosteum based 1st generations ACI but are not common after the scaffold based ACI. [46] Loose body formation can also take place if the hypertrophied cartilage piece gets separated.
Adhesions, arthrofibrosis and delamination [46] are the complications usually associated with an improper or poor postoperative rehab. A proper pre-operative counselling and a good postoperative team approach between the physiotherapist and the patient, are the crucial steps to reduce the chances of such complications.

Poor integration of the regenerative cartilage with the healthy surrounding cartilage, Insufficient regenerative cartilage fill etc are part of the partly or completely failed ACI procedure. [47] Patient must be warned of the failure risks before any ACI procedure.

Conclusions & Keypoints

The literature has consistently shown gradually improving results of ACI, from the 1st generation to the 3rd generation. There is a strong short-term evidence in favour of all the generations of the ACI procedures. However for long-term results, there are many case series that has shown good results with the 1st generation ACI; which needs to be watched for the 3rd generation techniques in near future. The 3rd generation ACI gives added advantages of fewer complications and ease of the surgical technique as compared to the previous generations. The gel based ACI provides a three-dimensional distribution of the cultured cells in a scaffold that is made of fibrin glue. It is comparatively an easy surgical procedure. However it should be chosen very wisely after a detailed clinical and radiological assessment of the patient. The procedure has a very specific sets of indications and contraindications, which must be followed diligently. Consideration of the biomechanics is a must before attempting the ACI procedure. Post-operative rehabilitation program is also very unique and is dependent on the site and size of the lesion. Management of concomitant pathologies, biomechanics can modify the post-operative rehabilitation.

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