



The Grosvenor Nuffield Hospital

Chester Knee Clinic

Wrexham Road Chester CH4 7QP

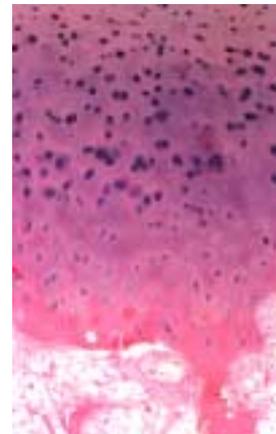
Telephone 01244 680 444

Fax 01244 680 812

Articular Cartilage Repair

WHAT IS HYALINE ARTICULAR CARTILAGE?

Hyaline articular cartilage is a complex structure, developed and progressively refined over hundreds of millions of years. Articular cartilage provides smooth articulation under variable loads and impaction for very long periods of time.



This tissue responds to alterations in use. It serves as the load-bearing material of joints, which has excellent friction, lubrication and wear characteristics. Hyaline cartilage has one of the lowest coefficients of friction known for any surface to surface contact. The cartilage thickness varies significantly across articular surfaces of the same joint. Although it is at most only a few millimetres thick, it has surprising stiffness to compression, resilience, and an exceptional ability to distribute variable loads. Normal hyaline cartilage has a glossy, bluish white, homogenous appearance, firm consistency and some elasticity.

DIAGNOSIS OF ARTICULAR CARTILAGE DEFECTS

The articular cartilage defect should be diagnosed and treated early, before it becomes a large and deep osteochondral defect. Generally, the diagnosis of articular cartilage injury is difficult and unreliable. Clinical examination, standard radiography and standard clinical MRI generally provide low sensitivity and insufficient diagnostic accuracy.

Arthroscopic examination: although arthroscopy is invasive and requires anaesthetic, it is still the most helpful diagnostic tool in experienced hands. Careful visual arthroscopic inspection, probing of articular surfaces and videoarthroscopic record (videoprint or stored digital image) are very useful and most of the time necessary. Your arthroscopic operation may be recorded on the videotape, and kept as a part of the hospital record and used for educational purposes.



Magnetic Resonance Imaging (MRI): standard clinical MRI is still unable to diagnose most articular cartilage injuries, especially if clinical suspicion is low. However, with advanced MRI techniques, special articular cartilage scanning protocols, and increased awareness of chondral injury, magnetic resonance imaging has begun to replace more conventional methods in evaluation of articular cartilage damage and repair. Magnetic resonance is already an effective method to diagnose chondral injury, to aid in the selection of therapeutic intervention and to assess the long-term follow-up of repaired articular cartilage. MRI has unique capabilities to evaluate cartilage non-invasively.



WHY IS ARTICULAR CARTILAGE REPAIR NECESSARY?

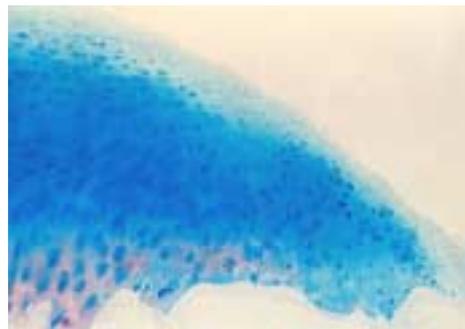
Cartilage is frequently injured, often as a result of sports related trauma, but due to its avascular nature, articular cartilage has very limited capacity for repair. It is well known that the capacity of articular cartilage for repair is limited. Partial-thickness defects in the articular cartilage do not heal spontaneously. Injuries of the articular cartilage that do not penetrate the subchondral bone do not heal and usually progress to the degeneration of the articular surface. Injuries that penetrate the subchondral bone undergo repair through the formation of fibrocartilage. Although fibrocartilage fills and covers the defect, this is the

wrong tissue from the biomechanical standpoint. The fibrocartilage is made to resist tension forces, while the hyaline cartilage is made to resist compression forces, to enable smooth articulation, and to withstand long-term variable cyclic load and shearing forces. Focal articular cartilage defects, often found in young adults, have been increasingly recognized as a cause of pain and functional problems. There is more and more clinical evidence that full thickness articular cartilage defects continue to progress and deteriorate, although at a slow rate. Early diagnosis and treatment of these patients is recommended prior to the development of more advanced osteoarthritis.

In selecting methods of restoring damaged articular surface, it is important to distinguish articular cartilage repair from articular cartilage regeneration. **Repair** refers to the healing of injured tissues or replacement of lost tissues by cell proliferation and synthesis of a new extracellular matrix. Unfortunately, the repaired articular cartilage generally fails to replicate the structure, composition, and function of normal articular cartilage. **Regeneration** in this context refers to the formation of an entirely new articulating surface that essentially duplicates the original articular cartilage. Therefore, the best we can do at present is to **repair** the chondral defect.

“It should be clear that cartilage does not yield its secrets easily and that inducing cartilage to heal is not simple. The tissue is difficult to work with, injuries to joint surface, whether traumatic or degenerative, are unforgiving, and the progression to osteoarthritis is sometimes so slow that we delude ourselves into thinking we are doing better than we are. It is important, however, to keep trying.”

Dr Henry Mankin, Boston, USA.



WHAT CAN BE DONE WITHOUT SURGERY?

A number of symptomatic options are available today for patients with chondral defects and patients with a moderated degree of cartilage degeneration. The weight-loss is probably the most important plan of this strategy, for obvious reasons. Regular exercise like walking and swimming are often very helpful but repetitive impact activities like jumping and running on tarmac are best avoided.

NEW PAIN MEDICATION: a new generation of “designer” pain-killers, or so-called COX-2 Inhibitors have introduced a potent and efficient pain management system, with reduced side-effects. The two COX-2 inhibitors on the market are Vioxx and Celebrex, and they represent the “best and brightest” of the new painkillers. It seems that these drugs have similar or better efficacy to the old nonsteroidal anti-inflammatory drugs (NSAID) but are safer in average-risk patients as they cause less gastrointestinal tract injury.

CHONDROPROTECTIVE AGENTS: the expanding knowledge of cartilage biochemistry and pathogenesis of osteoarthritis has focused research on slowing the progression of degeneration and promoting cartilage matrix synthesis. This research has identified substances, termed chondroprotective agents, which counter the arthritic degenerative processes and encourage normalisation of the synovial fluid and cartilage matrix. Chondroprotective agents are compounds that stimulate chondrocyte synthesis of collagen and proteoglycans, as well as synoviocyte production of hyaluronan, inhibit cartilage degradation and prevent fibrin formation in the subchondral and synovial vasculature. Examples of compounds that exhibit some of these characteristics are the endogenous molecules of articular cartilage, including **Hyaluronic acid, Glucosamine and Chondroitin sulfate.**

VISCOSUPPLEMENTATION THERAPY (hyaluronic acid): viscosupplementation is the term for a therapy that aims to be chondroprotective by restoring the fluid properties of the tissue matrix in osteoarthritis sufferers by means of intra-articular injections of highly purified “viscoelastic” solutions of sodium hyaluronate (HA, also known as hyaluronan). Intraarticular injections of hyaluronic acid (HA) are widely used in the Asian and European orthopaedic communities for controlling the pain and loss of joint function resulting from osteoarthritis. In more than 10 years, it has been used in approximately one million patients in 20 countries. The substance is hyaluronate, a naturally occurring viscoelastic agent that supposedly acts as a shock absorber and lubricant in the knee joint. Preliminary results of animal studies demonstrate that intraarticular injection of hyaluronic acid may have protective effects on articular cartilage. It is indicated for the pain in osteoarthritis of the knee in patients who have failed to respond adequately to non-operative treatment and other pain medication. HA is well tolerated with no demonstrable toxicity and few side effects. Because it is injected directly into the joint, the onset of action is fairly rapid. Possible mechanisms by which HA may act therapeutically include: providing additional lubrication of the synovial membrane, controlling permeability of the synovial membrane, thereby controlling effusions and directly blocking inflammation. However, the exact mechanisms of action, articular cartilage changes and short and long term results remain unknown.

MATRIX ENHANCEMENT THERAPY (glucosamine and chondroitin sulfate): numerous studies have demonstrated that **glucosamine** stimulates the synthesis of proteoglycans and collagen by chondrocytes. Since osteoarthritis (OA) results when cartilage breakdown exceeds the chondrocytes' synthetic capacity, providing exogenous glucosamine increases matrix production and seems likely to alter the natural history of OA. Glucosamine also has a mild antiinflammatory activity that is unrelated to prostaglandin metabolism. In randomised, double-blinded, placebo-controlled clinical trials using oral preparations, glucosamine salts have been verified as efficacious in the management of OA, and have not demonstrated any toxicity, severe side-effects, or abnormal clinical, biochemical, or hematological changes. **Chondroitin sulfate** is the most abundant glycosaminoglycan in articular cartilage. It plays an

important structural role in articular cartilage, notable for its role in binding with collagen fibrils. As a chondroprotective agent, it has a metabolic effect as well: its action is to competitively inhibit many of the degradative enzymes that break down the cartilage matrix and synovial fluid in OA. Because of the additional mechanism of action is via the prevention of fibrin thrombi in synovial or subchondral microvasculature, chondroitin sulfate has been investigated for its anti-atherosclerotic effect. When used together, it seems that glucosamine and chondroitin sulfate combine effects to stimulate the metabolism of chondrocytes and synoviocytes, inhibit degradative enzymes, and reduce fibrin thrombi in peri-articular microvasculature. Numerous clinical studies performed on horses at US veterinary schools have supported this combination and synergistic effect. Human randomised, double-blind clinical trials are currently underway.

ARTHROSCOPIC LAVAGE AND DEBRIDEMENT: lavage is one of the most basic of traditional arthroscopic techniques. Dr Robert Jackson, the pioneer of arthroscopy in North America, observed that in the course of performing diagnostic arthroscopies patients with intra-articular knee problems had significant pain relief following joint lavage. Exactly how arthroscopic lavage and debridement may help the early symptoms of osteoarthritis is still not entirely clear. Joint lavage removes loose intra-articular tissue debris and inflammatory mediators known to be generated by the synovial lining. In early stages, removing these degradative enzymes from the joint may allow chondrocytes to increase their biosynthetic activity. Another mechanism by which lavage may relieve the symptoms and increase the resiliency and stiffness of articular cartilage is through changing the ionic environment within the synovial fluid. Lavage may provide some patients with advanced degenerative disease of the knee, which may last as long as 3 years. However, the lavage provides only short-term symptomatic relief without correction of underlying pathology. If predisposing malalignment is not corrected, the beneficial effects seem to be minimised. The outcome of this simple procedure is generally insufficient for the active population.

CARTILAGE REPAIR TECHNIQUES

Historically there have been a number of attempts to develop clinically useful procedures to repair damaged articular cartilage, but these have not proved entirely successful yet. Treatment options are limited and the long-term outcome is still uncertain. Today's choice of surgical techniques that can restore and maintain **hyaline** cartilage is very limited. Current attempts to treat articular cartilage defects can be divided into three basic categories:

1. The bone marrow stimulation (**microfracture**).
2. Transplantation of **osteochondral autologous grafts (OATS or MosaicPlasty)**.
3. Transplantation or implantation of **cultured autologous chondrocytes (ACI)**.

1. MICROFRACTURE: this technique was developed and popularised by Dr Richard Stedman, from Vail, Colorado, USA. The treatment involves a disruption of subchondral bone in an attempt to induce bleeding (fibrin clot

formation) and to initiate primitive stem cell migration from the bone marrow into the cartilage defect site. These techniques utilise primitive stem cells, which are capable of differentiating into bone and cartilage under the influence of various biologic and mechanical intraarticular factors. The subchondral bone is penetrated in order to reach a zone of vascularisation, stimulating the formation of a fibrin clot containing pluripotential stem cells. This clot differentiates and remodels, resulting in a fibrocartilaginous repair tissue. Although fibrocartilage often appears to offer the patient significant pain relief, this tissue lacks several key structural components to perform the mechanical functions, as a wear-resistant and as a weight-bearing surface. The fibrocartilage repair tissue does not produce a proper compressive stiffness against applied mechanical load and thus is subjected to an excessive deformation under physiological loading. This in turn causes a mechanical failure of the repaired tissue and eventually leads to a recurrence of degeneration of the repaired cartilage.



2. OSTEOCHONDRAL AUTOGRAFT TRANSPLANTATION (OATS or MosaicPlasty):

osteocondral autograft transplantation seems to be the only surgical techniques that can restore the height and the shape of articulating surface in focal osteochondral defects, with composite autologous material that contains all necessary ingredients: hyaline articular cartilage, intact tidemark and a firm bone carrier. However, like many other orthopaedic procedures that require the use of autologous tissues, osteochondral autograft transfer is the "rob Peter to pay Paul" situation. The main problem with this reconstructive technique is the limited availability of autografts, which significantly reduces the choice of treatable defects down to a small focal chondral defect, and a long-term donor morbidity in multiple donor sites. Deep and large, crater-like osteochondral defects are not suitable for osteochondral autograft transplantation, mainly because of the limited availability of autologous osteochondral grafts. Also, it is difficult to reconstruct the subchondral bone and restore the contour of the defect area, and to cover the entire defect area with hyaline articular cartilage. The dead spaces between circular grafts, the lack of integration of donor and recipient hyaline cartilage, different orientation, thickness and mechanical properties of donor and recipient hyaline cartilage are further sources of clinical concern. For more information visit the website: www.isakos.com/innovations/oats.html.



3. AUTOLOGOUS CHONDROCYTE IMPLANTATION (ACI): although cartilage is unable to repair itself on its own, this advanced FDA-approved technology allows cartilage cells, known as chondrocytes, to be harvested from your knee and cultured and multiplied. The fresh chondrocytes are then reimplanted in your knee and cause hyaline-like cartilage to repair the defect in articulating surface. ACI, also known as Carticel treatment, restores the articular surface to your own hyaline-like cartilage without compromising the integrity of healthy tissue or the subchondral bone. Carticel has demonstrated important benefits in patients with a femoral focal lesion. If you have this type of lesion, then Carticel may be an appropriate treatment option. The procedure consists of two steps. The first is the harvesting of some healthy cartilage from your knee, which is done arthroscopically. This sample of cartilage is sent to the Carticel laboratory in Cambridge, Massachusetts, USA, and it is used to grow new chondrocytes, which are sent back to us after 4 to 6 weeks. The second step is the reimplantation of the cultured chondrocytes, or Carticel. This procedure is done through an arthrotomy. To derive maximum benefit from ACI, you should adhere strictly to the personalised rehabilitation plan recommended by your physiotherapist. This will include progressive weight-bearing, range of motion,



and muscle strengthening exercises which may begin as early as the day after surgery. When you successfully complete ACI and rehabilitation, you should be able to resume all normal activities, including sports. This is expensive tissue engineering technology that is not yet available in most NHS hospitals.

For more information visit the website:

www.genzyme.com/prodserv/tissue_repair/carticel/pi.htm

FUTURE TECHNOLOGIES

A technology superior to bone marrow stimulation and osteochondral autograft transfer in repairing the articular cartilage should become available fairly soon. Autologous or synthetic, non-resorbable or resorbable **matrices** and **scaffolds**, with or without added autologous chondrocytes and transforming growth factors (TGF's) are currently the most researched and the most exciting cartilage restoration technologies. Realistically, we should expect that over the next decade several new technologies, including improved autologous cultured chondrocyte implantation, tissue engineered articular cartilage, growth factors and acellular resorbable matrices, will enter routine clinical usage.

For more information visit:

<http://www.medscape.com/Medscape/OrthoSportsMed/journal/2000/v04.n01/mos0114.bobi/mos0114.bobi-01.html>. For further up-to-date and more specific information on cartilage repair techniques please visit the following websites: www.cartilage.org, www.medscape.com, www.aaos.org (go to Search and type: articular cartilage repair), or: <http://www.isakos.com/innovations/hyaline.html>.

Some articles are downloadable in the PDF format and you will need Adobe Acrobat Reader to read them. PDF (Portable Document Format) files duplicate the look and format, including all graphics, of published documents and can be read on any platform (IBM, Unix, Macintosh, etc.). In order to view and print PDF files, you must have Adobe® Acrobat® Reader software – go to <http://www.adobe.com/products/acrobat/readstep2.html> to download Acrobat Reader for free.

PRE-OPERATIVE CHECK LIST

- ✓ Bring your regular medication!
- ✓ Bring relevant medical documents and XR/MRI films with you.
- ✓ Tell us if you are allergic to any medication or food.
- ✓ If you are taking the contraceptive pill - you should stop taking the pill at least 4 weeks prior to your knee surgery!
- ✓ You can eat **solid food up to 6 hours** and **drink clear fluids up to 3 hours** before surgery.
- ✓ Check on the program on post-operative exercises and rehabilitation.
- ✓ Wear comfortable loose clothes and shoes.
- ✓ Arrange for someone to drive you home after day-case surgery.

WHAT HAPPENS AFTER YOUR OPERATION?

Recovery: after your operation is over, the arthroscopic portals are closed with sterile surgical tape and covered with a layer of gauze and crêpe bandage. If you find that your operated leg is painted pink or brown – don't worry! We use coloured skin prep routinely. If your cartilage repair operation required open knee surgery, the skin incision will be closed with continuous resorbable subcuticular stitch or a number of small metal skin clips. You will be moved from the operating room to a recovery room where a nurse will monitor your temperature, blood pressure and heartbeat. Some patients experience slight nausea, dizziness, fatigue, pain and feel cold. This is quite common and usually fades out after a couple of hours. Pain medication may be given orally, rectally or through an intravenous line. Cold pressure dressing may be applied to reduce swelling and discomfort. Once you are fully awake and all your functions are stable you will be transferred back to the ward.

Ward: Before being discharged, which ranges from several hours after your arthroscopic to a couple of days after the open knee operation, you will be seen by the ward physiotherapist. You will learn how to care for your portals, what activities you should avoid, and what exercises you should do to aid your recovery.

Before your go home: be sure that you know about any special instructions on taking pain medication, how to use crutches, which home recovery exercises to do, when to schedule your first follow-up appointment, when you can drive, when you can return to work and when you can return to sports and fitness activities.

Follow-up: at a follow-up visit (usually 10 to 14 days after the operation) your surgeon will inspect your skin incision and arthroscopic portals, remove the skin closure and discuss the operative findings and further rehabilitation program.

HOME RECOVERY AND REHABILITATION

The recovery time will depend on the joint problem, extent of surgery, your ability to heal and rehabilitation. Recovery time varies markedly from patient to patient. How quickly and fully you recover after arthroscopic or open knee surgery is, to a large degree, up to you. In any case, your knee needs special care at home. Elevation and ice can help control swelling and discomfort, and circulation exercises help prevent postoperative complications.

ELEVATION reduces swelling, which in turn relieves pain and speeds your healing. Elevation also helps prevent pooling of blood in your leg. To elevate your knee correctly, be sure to keep your knee and ankle above your heart. The best position is lying down, with two pillows lengthways under your lower leg. Elevate your knee whenever you are not on your feet for the first few days after arthroscopy.



ICE is a natural anaesthetic that helps relieve pain. Ice also controls swelling by slowing the circulation in your knee. To ice your knee use a bag of frozen peas or a plastic bag filled with crushed ice. Then wrap the ice bag with a small moist towel to protect your skin. Cover your knee with a blanket and leave the ice on for 30 to 60 minutes, several times a day, for the first 2 to 3 days after arthroscopy.

PAIN MEDICATION allows you to rest comfortably and start your exercises with a minimum of discomfort. It is a good idea to take your pain medication at night, even if you are not in severe pain, to assure a good night's rest. Pain often signals overactivity, so you might try rest and elevation to help relieve discomfort. Avoid alcohol if you are taking pain medication.

FIRST FEW MEALS after arthroscopy should include light, easily digestible food and plenty of fluids. Some people may experience slight nausea, a temporary reaction to anaesthetic.

CIRCULATION EXERCISES help prevent post-operative complications, such as blood clotting in your leg. Point and flex your foot, and wiggle your toes, every few minutes you are awake for a week or two after arthroscopy.

DRESSING keeps your knee clean and helps prevent infection. Be sure to leave your dressing on for 3 to 5 days, then remove the bandage and gauze (but leave surgical tape intact and do not worry if the gauze is a bit blood-stained!) and replace bandage with a new one. Use just enough tension to get the wrinkles out. Leave this light compressive dressing until your first follow-up appointment.

SHOWERS are fine if you put your leg in a large plastic bag taped above your dressing. Wait to take your first shower until you can stand comfortably for 10 to 15 minutes.

CRUTCHES may be prescribed to keep weight off your knee as it heals. You can weight bear (walk tiptoe or on the heel) as tolerated. Be sure you know how to set the hand rests and the right height for you (check with your physiotherapist before you leave the hospital). Try to walk normally and keep your body upright. **Your crutches should move with your bandaged leg.**

WALKING helps you regain range of movement in your ankle, knee and hip. A combination of joint movement and weight bearing are essential for normal joint nutrition and proprioception. Even if you are on crutches and not yet bearing full weight on your leg, you should start walking as soon as possible, to improve circulation and speed the healing process in your leg. Gradually put more weight on your leg and try to keep your ankle, knee and hip bending as normally as possible. Some cartilage repair procedures (ACI) will require non-weight bearing for a couple of weeks.

FOOTWEAR use shoes or trainers with semi-soft thick sole, and with good arch support

EXERCISES are very important after knee surgery! Rebuilding the muscles that support and stabilise your knee (quadriceps, hamstrings and calf muscles) is one of the best ways to help your knee recover fully. **Please consult your physiotherapist and ask for a separate illustrated brochure with detailed exercises.** The sooner you start these exercises, the better. You will get the most benefit from these exercises if you do them with slow, steady movements, and on both legs to maintain your muscle balance. Some patients may need special equipment and supervised physiotherapy.

DRIVING is usually possible after a couple of days. However, it may take several weeks before your driving is back to normal, especially if your thigh muscles were weak before the operation.

RUNNING should be avoided for at least 2 to 3 months, especially on hard surfaces (tarmac). Generally, try to avoid repetitive impact, for as long as possible.

RETURN TO WORK only after your surgeon feels it is safe. It could be a few days or a few weeks, depending on how quickly you heal and how much demand your job puts on your knee.

COMPLICATIONS, although uncommon, do occur occasionally during or following diagnostic and surgical arthroscopy. They include excessive swelling or bleeding, joint infection, phlebitis, blood clots and very rarely technical problems with arthroscopic instruments. There are also anaesthetic risks, both during and after the procedure, but they are minimal.

PROBLEMS? Please contact your **GP** if you bleed or discharge continuously from arthroscopic portals, if you have a fever of 101⁰ or above, severe nausea, increased pain unrelieved by medication and rest, increased painful swelling unrelieved by elevation and ice, pain in the calf, shortness of breath, chest pain or abnormal coughing.

REHABILITATION QUESTIONS: if you have any questions or problems with your rehabilitation please contact **Physiotherapy Department** on 01244 684 314.

APPOINTMENTS: if you wish to change the time or the date of your appointment please call **Consultation Booking** on 01244 684 318.

HOW TO FIND US? The Grosvenor Nuffield Hospital is located on the southern outskirts of Chester. If you are driving, we are on the A483, towards Wrexham. There is ample parking space for you and your guests.

