Special Focus: Rehabilitation

Global Concepts for Successful Joint Restoration
**AMIC® Talus**

Autologous Matrix Induced Chondrogenesis

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**An innovative, biological technique for the treatment of cartilage defects in the talus**

> A minimally invasive, one-step surgical technique for the treatment of chondral and osteochondral lesions larger than 1 cm²
> Based on microfracturing, the established first-line treatment
> Natural protection of the super clot resulting from Chondro-Gide®’s unique bilayer structure
> Positive influence of the chondrogenesis through Chondro-Gide®
> Marked reduction in discomfort, even after resumption of sports activities
> Promising clinical results
> Straightforward, cost-efficient surgical technique

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Clinical results and scientific studies confirm the effectiveness of Chondro-Gide®, the leading collagen matrix in cartilage regeneration.

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Geistlich Pharma AG
Bahnhofstrasse 40
CH–6110 Wolhusen
www.geistlich-surgery.com

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**CARTILAGE REGENERATION**
First Announcement

ICRS Focus Meeting 2012 – Foot and Ankle
Aug 30 to Sept 1, 2012 at the FIFA Auditorium Sonnenberg, Zurich/Switzerland

The ICRS Focus Meetings in Zurich concentrate every year on a different joint, the Ankle in 2012, following the idea, that a complete and in-depth understanding of joint function and associate pathologies is a prerequisite for successful cartilage repair.

The venue at the FIFA convention center in Zurich with its personal and exclusive setting perfectly suits this idea allowing for intense discussions and uninhibited questioning of a world class faculty in an exclusive & intimate environment. International renowned specialists and opinion leaders in the field share their knowledge on an utmost professional level. Attendees from all over the world learn about the newest developments and tools for a successful treatment of ankle joint & cartilage lesions.

Foot and Ankle are not commonly in the main focus of cartilage repair – but pain and loss of function in this area due to injury and overuse are quite frequent. Osteochondritis dissecans of the talus, cartilage lesions due to instability, osteoarthritis of the first MTP Joint, achilles tendon rupture/tendinosis – to name a few disorders sport physicians and surgeons face in their clinics. A first class international faculty will address these and other topics and present new and established treatment techniques as well as pitfalls and pearls. Elite athletes will discuss the implications of foot and ankle problems for their career. The very personal atmosphere of the FIFA auditorium Sonnenberg in Zurich enables vivid discussions, direct networking and support for specific cases. Industry representatives will demonstrate the latest developments in the field. Last but not least – Zurich will host the first diamond league track and field meeting after the Olympic games – meet the stars at the Zurich Letzigrund stadium – ICRS will have some tickets!

Mark your agenda – and stay tuned!

The Course is limited to 120 participants

Autologous Matrix Induced Chondrogenesis

Chondro-Gide® is not available in all markets. Availability is subject to the regulatory or medical practices that govern individual markets.
Clinical studies show MACI® implant to be an effective solution for articular cartilage repair demonstrating:1,2,4

- the ability to generate hyaline-like cartilage as early as six months after implantation4

- long-term (5-7 years) clinical improvement and durability of regenerated cartilage2,5,8

- technically simpler and faster than traditional ACI with comparable clinical results and options for arthroscopic delivery3,6,7

With over 26 000 patients treated, Genzyme has more than 15 years of clinical experience in autologous cartilage repair, continuously ensuring quality and compliance.9

www.maci.com

References:
2 Jagiello, M. J., Rogers, B., Briggs, TWR. Sequential Outcome Improvement Following Autologous Chondrocyte Implantation - 7 Year Follow Up, abstract (No. 182) presented American Academy of Orthopaedic Surgeons (AAOS) annual meeting, San Diego, February 2007.
9 Data on file.

MACI implant is not approved for use in the USA by the FDA, it is commercially available in Australia and select European/Asian countries.

www.maci.com

Genzyme A Sanofi Company, Genzyme Europe BV
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Presidents’ Voice

As December is rushing in and the year is coming to a close end we are now ready with the last newsletter of the year 2011, focused on rehabilitation issues after cartilage repair. We have received many contributions from 13 different countries and 4 continents. It is a nice example of the “special focused” newsletters, that the communications committee and our executive office has recently introduced. The newsletter is a very nice way of sharing with you our current activities, ideas and other things going on in our society. So far it is clear that 2011 as been a very busy, very successful and very energetic year. Not only have we done a couple of successful skills courses both basic science and surgically, but we have also been active in restructuring the society, implementing the new organization and becoming more professional in the way we run the committees, the board and the society overall. I clearly feel we have been successful in involving new people, creating additional momentum and setting-up new collaborations.

The recent special edition Articular Cartilage Injury in the Football (Soccer) Player of our Journal “Cartilage” that Sage produced for us in collaboration with FIFA is a nice example of such a new project. The way in which Kai Mithoefer pulled together all the expertise and built a strong presence of Cartilage interest in literature combining insights on football, athletes needs and cartilage treatment is exceptional, my compliments and thanks!

This edition of the newsletter includes pieces from Anthony Hollander our vice president on a new meeting initiative while Norimasa Nakamura our secretary updates you on the recent activities of the executive committee. Many other contributors show clearly how many people are involved and the diversity of activities which are actively pursued within ICRS. To choose one or two as a highlight here might be selling others short, however I did choose a few to bring this fact to your attention.

I also would like to bring to your attention the continued energy, high quality and proactive way in which Chris Erggelet is active in the ICRS as a faculty member on many courses, as chairman of the financial committee and as one of the people instrumental to the new professional business set-up of our executive office. Chris, Susan Chubinskaya and our office have been very effective in collaborating with our accountants which has provided us with essential management information, a solid understanding of our financial position and a thorough analysis of strategic consequences of the decisions our board has been able to make. This is a perfect basis for next year as well as a professionalization of the future.

Next I would like to point you towards our website and the new ICRS Edugrid. The educational activities grid is a good exemple of how we listen to our members’ comments and create new activities to provide better value for membership. This year has shown that we do not need to change to an annual world congress but rather as a boutique society can cater to the local needs in certain regions and work alongside initiative of our members to set up educational events. The introduction of the Summit Meeting and the ICRS Think Tank are two great new meeting formats that alongside the world congress, focus meeting and the skills courses allow us to apply various meeting sizes and formats, all in our attempt to advance science and education in cartilage repair worldwide.

The efforts of both the local committee of Montreal 2012 and the program committee have set us up for another high level international event. The 2012 ICRS world congress promises to be a memorable one. The number and quality of abstracts currently under review is high and the interest for the meeting is very good both from sponsors and members alike. Don’t forget to mark your calendar, book the meeting and for sure see if you can slip in some extra time to enjoy what Montreal / Canada can offer to you.

Finally it is almost time for our members to nominate and elect the new committee members, chairs and a few other essential positions to govern and guide our society into the future. We have been very fortunate by increasing not only our number of members but more importantly the number of people actively involved. So please keep an eye out for the upcoming call for nominations and refer to the bylaws for instructions on how to become actively involved in how we can develop ICRS for a successful future.

Let us know your thoughts and reach out to others within ICRS via LinkedIn: www.linkedin.com/groups/ICRS

Sincerely,

Daniel Saris, ICRS President

Holiday Season

The ICRS wishes you a very happy and peaceful holiday season with your families.

The Cartilage Executive Office will be closed from December 23, 2011 until January 2, 2012.
It is my pleasure to be able to announce a new venture for the Society, the ICRS Summit, that we hope will become a regular and prestigious meeting in our calendar. It will be held every 18 months, half way between the World Congresses. The aim will be to bring together key opinion leaders from scientific, clinical and industrial sectors of the cartilage repair community in order to take a fresh look at the state of play in the field and to influence the strategic direction of cartilage research around the world. Data will be presented under strict rules of confidentiality so that the very latest work can be discussed without fear of inappropriate disclosure. A short summary of the meeting will highlight key observations or consensus recommendations emerging from the event.

This will be a small meeting with a select group of 60 – 80 attendees who will include a mixture of 10 - 20 invited Faculty and up to 50 other participants who will be selected through an application procedure. Some of the participant places will be reserved for young clinicians and scientists and they will receive a bursary towards their travel. It is anticipated that there will be heavy competition to be able to attend this influential event. Therefore we will develop a robust review process that will allow us to select the strongest applicants who can justify a place at the meeting based on their contribution to cartilage education and research as well as their involvement in previous ICRS activities. At the same time we will ensure a good balance of the different participating groups.

The President of the ICRS will host the Summit and set the agenda for the meeting. As I will be taking over as president after the Montreal World Congress in May 2012, I will have the responsibility of organising the first Summit, which will be in the early spring of 2013. The exact date and venue will be confirmed as soon as possible along with details of the application and selection process. I hope that all members of ICRS will aspire to become participants in an ICRS Summit one day. This new meeting will help us in our strategic goal: “Advancing science & education in cartilage repair worldwide!”

Anthony Hollander, ICRS Vice President

The Executive Board meeting of the ICRS was held between September 30 and October 1, 2011, at the Swissotel Zurich, Oerlikon. Due to the geographical diversity of the Executive Board members, a Skype conference call is usually used for the monthly meetings. However, this time the Executive Board and the Executive Office have sought the chance for a real meeting in order to enable extensive discussion on important issues including future strategic planning.

Throughout the two-day strategic retreat, the 5 board members devoted themselves to extensive discussions on many issues related to the current governance and to the future strategic planning of the society in a face-to-face way. The effect of these discussions was drastic and much more than we expected. Very clear and strong strategies have been developed for the future of this unique and important international society. After this fruitful meeting, all the members got together to have an excursion to a lovely small town near Zurich called Wetzikon, where the Cartilage Executive Office is located. Followed by the visit to our Head Office, we finished the meeting with a wonderful Italian lunch, celebrating the success of the meeting and confirming the strengthened friendship among the participants.

Norimasa Nakamura, ICRS Secretary General

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### Mark your Agenda

- **4th ICRS Laboratory Skills Course in Translational Science**
  - Tromso, Norway June/July, 2012 (dates to be defined)
- **2nd ICRS Focus Meeting – The Ankle – FIFA Auditorium, Zurich, Switzerland**
  - August 30 – September 1, 2012
- **5th ICRS Surgical Skills Course – Washington, Richmond, USA**
  - October 04 – 06, 2012
- **3rd ICRS Focus Meeting – Cartilage Imaging – Medical University Center, Vienna, Austria**
  - December 07 – 08, 2012
Welcome to New Members

Renewal of your ICRS Membership 2012

Being an active member of the ICRS Network is to be part of the Worldwide Cartilage Community and to fully benefit from one of the most dynamic specialized orthopaedic networks in the world.

We would like to kindly remind all our members that the renewal of the Membership within the ICRS is automatic as per bylaws and becomes effective always in December for the upcoming year. If a member does not want to renew its membership for 2012, a short written notice of cancellation should be sent to our office by email until December 20. Please proceed to pay your membership online until January 30, 2012 by accessing your personal member account and you will not miss the journal “Cartilage” which can only be sent to members with paid fees 2012. If you need further assistance please contact our executive office by email: office@cartilage.org.

Changed your contact details?

After accessing your personal ICRS member account, do not forget to check/update your personal information and contact details. It is the member’s responsibilities to keep its data updated. If you have any problems in accessing your ICRS account, please contact our office by phone: +41 44 503 73 70 or by email office@cartilage.org.

ICRS Welcomes 88 New Members (since August 2011)

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| Kamich             | Amanda       | Bedford     | USA |
| Manicourt          | Daniel       | Brussels    | Belgium |
| Miller             | Stuart       | Baltimore   | USA |
| Mojtahed Jaberi    | Fereidoon    | Shiraz      | Iran |
| Pierri             | Carlos A.    | Florianopolis | Portugal |
| Pinheiro Silva     | J Miguel     | Oeiras      | Switzerland |
| Reiss              | Eric         | Oftringen   | USA |
| Schuff             | Louis        | Mandeville  | USA |
| Sibarani           | Tangkas      | Surakarta   | Indonesia |
| Simonaro           | Calogera     | New York    | USA |
| Strazar            | Klemen       | Ljubljana   | Slovenia |
| Sarensen           | Finn         | Árhus V     | Denmark |
| Van der Kraan      | Norio        | Fukuoka     | Japan |
| Van Roermund       | Peter        | Nijmegen    | Netherlands |
| Varughese          | Jacob        | Kochi       | India |
| Witteveen          | Angelique    | Nijmegen    | Netherlands |
| Zagallo            | Monica       | Faenza (RA) | Italy |
| Alarcon            | Marlon       | Guayaquil   | Ecuador |
| Caborn             | David        | Louisville  | USA |
| Canales            | Angelo       | Santiago    | Chile |
| Castro             | Marc A.      | Makati City | Philippines |
| Catan              | Rene         | Rizal       | Philippines |
| Chandy             | George       | cochin      | India |
| Choularas          | Vasileios    | Ioannina    | Greece |
| Dervin             | Geoffrey     | Ottawa      | Canada |
| Hollanda           | Joao         | Sao Paulo   | Brazil |
| Jacobi             | Matthias     | St. Gallen  | Switzerland |
| Jorge              | Pedro        | São Paulo   | Brazil |
| Karpstein          | Adriano      | Curitiba    | Brazil |
| Kaspis             | Panayiotis   | Larnaca     | Cyprus |
| Kevin              | Lee          | Singapore   | Singapore |
| Kisiday            | John         | Fort Collins| USA |
| Makris             | Eleftherios  | Davis       | USA |
| Matsuishi          | Takehiko     | Kobe        | Japan |
| Rawal              | Ashish       | Elmhurst    | USA |
| Salata             | Michael      | Cleveland   | USA |
| Shapiro            | Ian          | Appleton    | USA |
| Sibarani           | Tangkas      | Surakarta   | Indonesia |
| Singhal            | Anil         | Bulandshahr | India |
| Slomczykowski      | Michal       | Wolhusen    | Switzerland |
| Tsapralis          | Kyrakos      | Bologna     | Italy |
| Valladares         | Nicolas      | Guadalajara | Mexico |
| Varoga             | Deike        | Kiel        | Germany |
| Zangger            | Philippe     | Lausanne    | Switzerland |
Report from the ICRS/Genzyme Travelling Fellowship 2011

Patrick C. McCulloch, USA/Marco Demange, Brazil/Takehiko Matsushita, Japan - This was another exciting year for the ICRS Travelling Fellowship programme, sponsored by Genzyme since 2005. It brought together a diverse group of orthopaedic surgeons from around the globe for a tour to some of the top cartilage repair and research centres in Europe. After a highly competitive selection process, the following surgeons were selected: Patrick McCulloch from the Methodist Hospital in Houston, USA, Takehiko Matsushita from Kobe University in Japan, and Marco Demange from São Paulo University, Brazil. Each of the Fellows had a demonstrated interest in clinical treatment and research within the field of cartilage repair. They were joined by the “Godfather” of cartilage surgery, Lars Peterson from the University of Gothenburg, Sweden. “The opportunity to spend time with one of the greatest pioneers in orthopaedic surgery and cartilage restoration was the most enjoyable and rewarding aspect of the entire experience,” noted Patrick. Lars Peterson has been instrumental in the fellowship and has travelled with the Fellows since the program’s inception. Lars shared his knowledge of cell therapy, sports medicine, and the challenges and rewards of bringing new treatments from the bench to the bedside.

The tour began in Rostock, Germany at the ICRS Surgical Skills Course. Takehiko appreciated “the opportunity to meet great instructors and surgeons from around the world”. He added, “I learned fundamental knowledge about cartilage repair and related problems through the lectures and labs”. The Fellows all felt that the course was well-organized by Peter Cornelius Kreuz, and served as welcome introduction to many of the generous hosts they were scheduled to visit in the following weeks.

From Germany, the fellows travelled to Zurich where they spent time with Matthias Steinwachs at the Schulthess Klinik and with Chris Erggelet, who were both very generous hosts. They gained exposure to the use and science of membrane-assisted microfracture, bone marrow aspirates and platelet-rich plasma. A day trip to Davos afforded the opportunity to tour the AO Institute and learn about their recent focus on cartilage and stem cells. Whether discussing directions for future research over a lakeside dinner or while enjoying an apple strudel after a hike through the Alps, the Fellows unanimously found Switzerland both gorgeous and stimulating.

The next stop was at the famous Rizzoli Institute in Bologna, Italy. Elizaveta Kon, Maurilio Marcacci, and Francesca Vannini and their entire group enthusiastically welcomed the Fellows. Their work in developing scaffolds was particularly impressive to the travellers. Just as memorable was the extensive social program, with activities such as a day trip to the Uffizi museum in Florence, and ample opportunities to sample their fine wines and cuisine. The Fellows concluded that their hosts don’t just know how to work, they know how to live!

In Belgium, the Fellows visited Ghent and Leuven. Peter and Rene Verdonk were gracious hosts and invited the group to speak at a meeting of the Belgian Knee Society. Demange was particularly excited that “meniscus transplantation is performed in only a few centres in Europe, and we were able to observe two cases during our brief stay in Belgium”. The group jokingly responded that it was difficult to remember what else they learned there following a private tour of the legendary Duvel (meaning “Devil”) Brewery, famous for its strong beer. In the Netherlands, the group was welcomed by the ICRS President Daniel Saris and his team in Utrecht. The Fellows were very impressed with their comprehensive clinical and research programs. Many interesting cases were observed while staying in the Netherlands, including several cell therapy cases. In addition, a visit to R.J. van Heerwaarden allowed the group to learn about the latest research on osteotomies and joint distraction. The trip concluded in Amsterdam with a memorable scenic tour of the city by canal boat followed by a fabulous farewell dinner, all arranged by Marijn Rutgers. The Fellows wish to express their gratitude to Lars Peterson and all of the hosts who were so generous with sharing their time and expertise. Genzyme is to be commended for their continued support in making this experience possible. The ICRS is dedicated to building an international community with a shared interest in helping to expand the field of cartilage repair and summarized by Patrick, “This fellowship is a prime example of putting these principles into practice for the advancement of science and the betterment of patients worldwide.”
Articular Cartilage Injury in the Football (Soccer) Player
Kai Mithoefer, USA – Football (soccer) is the most popular sport worldwide with more than 300 million players globally and participation in this dynamic sport continues to grow. Articular cartilage injury has been increasingly observed in football (soccer) players and often limits the ability to play. In addition, the high chronic joint demands in this sport frequently lead to progressive joint degeneration and often permanent disability. The FIFA Medical Assessment and Research Center (F-MARC) and ICRS have recognized the enormous impact of articular cartilage injury for the football (soccer) player and have found a common goal in addressing the high incidence of acute and chronic joint injury in football (soccer) players. The upcoming special issue in the journal “Cartilage” presents an important part of a unique collaboration between FIFA and ICRS aimed at advancing the science and understanding of the articular cartilage injury and degeneration in the football (soccer) player and the options for its treatment and prevention. Following the successful FIFA “11 for health” concept this special issue has been published online on November 11, 2011 and features 11 articles that provide a comprehensive overview of the current knowledge of cartilage injury pathophysiology, epidemiology, and etiology and offers an up-to-date look at existing management algorithms, developing treatment options, and prevention strategies for the football (soccer) population. This issue provides a compact reference for players, coaches, medical staff, and researchers working with football (soccer) players. Furthermore, it intends to act as a catalyst for the advancement of science and education of cartilage injury in football (soccer).

Upcoming ICRS book
“Developing insights in cartilage repair”.

Pieter Emans, NL
The ICRS and Springer Science + Business Media are pleased to announce a partnership aimed at producing a series of books which will provide a collection of comprehensive educational resources to all involved in cartilage repair. The book series will be a condensation of the actual state of the art of current research and clinical applications, and will not only describe different strategies to repair cartilage defects but also explore fundamental research concerning cartilage biology and cartilage imaging, which is in line with the objectives of the ICRS “bringing together basic scientists, clinical researchers, and clinicians”. The series will take advantage of the cross-talk between clinical practice and fundamental research fostered by the ICRS to enable fast clinical implementation of novel findings to optimize cartilage repair.

The aims of the series are:

• To be available in both hard copy and electronic formats.
• To provide education and insight of cartilage and its repair to physicians and scientists with an active interest in Cartilage Repair and new transplantation techniques.
• To improve patient care through minimal invasive cartilage repair procedures
• To promote the exchange of ideas and information to further define the role, direction and goals of Cartilage Repair as a subspecialty of Orthopaedics.
• To foster integration of basic and clinical science.
• To facilitate the translation of that science to healthcare and clinical practice.
• To make young doctors, investigators and researchers enthusiastic to start and/or continue research in the field of Cartilage Repair.

Through the combination of the clinical and scientific expertise within the ICRS with Springer’s multimedia global presence and position as the largest book publisher within the Scientific, Technological and Medical arena, together we intend to provide the gold standard in educational resources for professionals involved in cartilage repair the world over, for years to come.

For further information please contact: pieteremans@gmail.com
Get ready for the 10th ICRS World Congress à la Montréal at the Hotel Fairmont – The Queen Elizabeth from May 12–15, 2012

Michael Buschmann, Montreal – The 10th World Congress of the International Cartilage Repair Society 2012 is now in advanced stage of preparations. Abstract submissions this year have reached a total of 450 submitted abstracts and the review process is currently in progress. The programme committee with its chairs Jos Malda and Wayne McIlwraith have spent long hours carefully piecing together an exciting cadre of invited speakers and session topics spanning new technologies, clinical studies, and methodological developments in cartilage repair and related areas (disc, meniscus).

The congress venue is centrally located in downtown Montreal offering direct access to a wide spectrum of cultural events and attractions of this city that is often thought of as at the crossroads of North America and Europe. Montréal features modern facilities and attractions against a backdrop of European history and charm.

Take advantage of a limited number of highly reduced early bird registration fees, available until February 29th, 2012 and please book your hotel accommodation at the official congress Hotel Fairmont, offering specially reduced congress room rates. Political dignitaries including the Queen Mother, Queen Elizabeth II, Prince Charles, Mikhail Gorbachev, President Jimmy Carter and Henry Kissinger stayed at the Hotel Fairmont Montreal. The celebrity guest list covers also many artists and, perhaps most famous of all, John Lennon, who held his famous ‘bed-in’ in 1969 in Suite 1742, where the song “Give Peace a Chance” was written and recorded.

Among all hotel reservations of the ICRS group received by the Hotel Fairmont until March 30, we will draw the lucky name of the person who will be upgraded to the famous John Lennon Suite #1742.

Hotel Reservations should be done early and directly at the Hotel Fairmont or through the ICRS Congress website. For further information please visit our website www.cartilage.org

On behalf of the local organizing committee, I would like to welcome all participants to Montreal and am looking forward to an enjoyable and productive meeting.

Invitation to the Industry – ICRS 2012

The cartilage repair market takes centre stage in Montreal. We invite all companies, whose technologies can diagnose, rehabilitate, repair, protect or regenerate cartilaginous surfaces of joints (stem cells, growth factors, PRP, bioactive composites, synthetics, scaffolds, allografts and combinations of thereof) to join us as exhibitors and/or sponsors for this most important event for professionals and key decision-makers in clinical cartilage repair and basic cartilage research. This is the opportunity to participate in a truly global meeting in this rapidly expanding field, with an expected attendance of over 1000 participants from more than 60 different countries.

For more information please contact Mr. Stephan Seiler at sseiler@cartilage.org.

We’re well positioned to host your convention.

At Fairmont The Queen Elizabeth, you’ll be uniquely situated to explore the sights of one of the most vibrant cities in North America! Famous for John Lennon and Yoko Ono’s Bed-in for peace, this landmark hotel is located downtown, above the train station, it is connected to the underground city, the subway system and is steps away from fabulous shopping and entertainment. Facilities include a 24-hour Health Club, an indoor pool, a lively bar-lounge and two fine restaurants, including the award-winning Beaver Club, where you can enjoy market-fresh inspired cuisine. ICRS attendees will experience Montréal’s joie de vivre at its best at the Queen E!
<table>
<thead>
<tr>
<th>Date</th>
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<tr>
<td>20.01 – 21.01, 2012</td>
<td>Freiburger Knorpeltage</td>
<td>Universität Freiburg, Freiburg, DE, <a href="http://www.freiburger-knorpeltage.de">www.freiburger-knorpeltage.de</a></td>
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<td></td>
<td>4th ICRS Laboratory Skills Course in Translational Science (Hands-on)</td>
<td>Tromso, Norway, (Meeting dates &amp; venue to be confirmed)</td>
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<tr>
<td>04.10 – 06.10, 2012</td>
<td>5th ICRS Surgical Skills Course</td>
<td>International Cartilage Repair Society, Washington - Richmond, USA, (Meeting dates &amp; venue to be confirmed), <a href="http://www.cartilage.org">www.cartilage.org</a></td>
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<tr>
<td>06.12 – 08.12, 2012</td>
<td>3rd ICRS Focus Meeting – Cartilage Imaging</td>
<td>International Cartilage Repair Society, Vienna Medical University, Radiology/MR, AT, <a href="http://www.cartilage.org">www.cartilage.org</a></td>
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This listing is not complete and does not constitute a recommendation or endorsement by ICRS. Further investigation by interested parties is always necessary. For further information, visit the ICRS online event calendar at our website.
3rd Laboratory Skills Course, Montreal, Canada

Michael Buschmann, Canada – The 3rd ICRS Laboratory Skills Course for Translational Science was held at Ecole Polytechnique in Montreal from May 31 to June 3rd this year. The course directors, Michael Buschmann, Anik Chevrier, Caroline Hoemann and Mark Hurtig, organized a 4 day hands-on workshop with modules in Biomaterials, Biomechanics, Histology and Animal Models.

The international cohort of 32 students included 30% from industry and 4 orthopedic surgeons amongst the mainly basic science group. Industry Sponsors included Piramal and Biomomentum. Biomomentum also organized and taught the laboratory component of the cartilage biomechanics module, bringing industry expertise directly to the benchtop. The daily laboratory activities and demonstrations were complemented by noon hour lectures in cartilage science (Robin Poole), cartilage repair (Kai Mithoefer), meniscus repair (Patrick Lavigne) and regulatory aspects (Matthew Shive). The resounding success of the course can be appreciated from the post-course survey where the quality, content, organization and appropriateness of the course had more than 90% of responses in the Excellent or Very Good category. On behalf of the course directors, I would like to say that a great time was had by all and we look forward to another similar event in Montreal in the near future.

1st Focus Meeting – The Hip, Zurich, Switzerland

Chris Erggelet, Switzerland – On June 9, 2011 the ICRS launched a new format in cartilage education with the opening of the first ICRS Focus Meeting by Jiri Dvorak, Member of the FIFA Medical Committee, Daniël Saris, President of the ICRS and Chris Erggelet, Course Director.

The Focus Meetings concentrate on one specific joint (the HIP in 2011), following the idea, that a complete and in-depth understanding of joint function and associate pathologies is a prerequisite for successful cartilage repair. The venue at the FIFA convention centre in Zurich with its personal and comfortable setting, perfectly suited this idea allowing for intense discussions and uninhibited questioning of a world class faculty. International renowned specialists and opinion leaders in the field shared their knowledge on a utmost professional level. Attendees from 24 countries learned about the newest developments and tools for a successful treatment of hip-pain and cartilage lesions.

The welcome cocktail held on the FIFA terrace overlooking the city, mountains and the lake of Zurich, and the congress diner in the famous Dolder Grand Hotel further facilitated networking and the exchange of ideas and projects. The ICRS Focus Meetings intend to close a gap in cartilage education.

Between the world congress for a complete overview of all activities in cartilage repair and the laboratory/surgical skills courses for hands-on experience, the Focus Meetings provide in-depth information regarding all aspects of a specific joint.

That said – mark your agenda for the ICRS Focus Meeting 2012 – Foot and Ankle from Aug 30 to Sept 1, 2012 Zurich, Switzerland!!!
Educational Events – Reports

4th ICRS Surgical Skills Cadaver Course; Rostock University, Anatomical Institute; Aug 25-27 2011; Cartilage Repair: See it, understand it, do it

Peter Cornelius Kreuz, Germany – We are looking back at the first German ICRS Surgical Skills Course held from August 25 – 27, 2011 at the University Medical Center in Rostock, Germany. During that 3-day hands-on and lecture-based course, worldwide leading physicians and experts repaired the latest information, tips and tricks of all options in the surgical treatment of chondral lesions.

The course was sold out long in advance. It included core lecture modules for cartilage and osteochondral repair including biomaterials, biomechanics with osteotomies and patella balancing, histology, mini implants and surgical techniques. In order to optimize the learning-process and to improve the instruction, 11 live-demonstrations had been included.

The motto of our course was: “Cartilage Repair – Understand it, see it, do it” and each module started with a keynote lectures in the area, followed by live demonstrations and finally by a hands-on learning on human cadaver specimens under close assistance of our faculty members.

The event brought up numerous highlights every day. One day before the workshop started, Lars Peterson and I went together with the 3 Fellows of the ICRS-Genzyme Fellowship - Programme to the Petrikeller to have our first dinner as a kick-off meeting. In this special restaurant with typical medieval food and customs held during the meal, the maidservants welcomed us as custom had it at that time. Therefore we could drink from mugs made of clay and the cutlery consisted of our 10 fingers and a simple knife. Bread was broken into pieces and shared between all of us and the entire dinner was eaten with our hands. The jovial atmosphere was underlined by Lars’ excellent knowledge on the history of the Vikings and of course all about cartilage repair.

After this “first instructive hands-on workshop” our congress started the following day at the Anatomic Institute of the University of Rostock. As a special highlight we could welcome Prof. Wree, head of the Anatomy, Prof. Mittemeier, Chief of the Department of Orthopedic Surgery of the University Medical Center and Prof. Schareck, who is the overall Director of the University of Rostock. Some months ago he was elected being the best director of all universities of Germany.

After the first presentations about cartilage anatomy and basic science, Prof. Wree and his colleagues showed during the first live-demonstration the steps from cartilage biopsy to its preparation, fixation, staining and histological evaluation. After the excellent lecture from Bert Mandelbaum about prophylaxis of cartilage lesions, the second live-demonstration was given by 6 Karateka of the TSV Rostock South Sports Club. The athletes, aged between 11 and 74 years, presented in a perfect manner advanced techniques in neuromuscular coordination including the disciplines Kihon, Kumite, Kata and Bunkai. Just shortly before the demonstration the first seat row at the lecture hall was suddenly abandoned by our participants and consequently nobody was hurt. During the welcome reception in the exhibition hall everybody could talk to each other, change experiences and get updated with the latest products by our industrial partners. Afterwards faculty members could enjoy the warm summer evening on the 2nd floor of the fish restaurant Borwin which has a nice view over the harbour of the river Warnow and the sailboats during sunset.

The second day included a very tough programme and started as early as at 7 o’clock in the morning. To wake up the audience, we started the first session with a mini-battle between me and Bill Rodkey. During my presentation I demonstrated together with a participant from Brazil the way to prepare cartilage lesions on a pig knee under controlled pressure by using the weight of 3 bottles of beer. Consistent with a “real mini-battle” conducted by Mats Brittberg the discussion revealed small differences. However, there is nothing that could interfere in the friendship between me and Bill. After some further lectures about different cartilage repair techniques including osteochondral repair, stem cells and autologous chondrocyte implantation, a small coffee break was necessary in order to be able to concentrate on the next live demonstration of Daniel Saris and Stefan Nehrer. In a very professional manner they showed the way of preparing cartilage lesions, to evalu-
Educational Events – Reports

Educational Events – Reports

ate cartilage defects and different treatment options during a knee arthroscopy in the lecture hall on a human cadaver via 2 cameras.

ACI was demonstrated by Sven Anders on a pig model. During the first workshop in the anatomic hall all participants had the opportunity to train the techniques as demonstrated before under the assistance of our international faculty. Then a lunch with a nice buffet awaited us in the SAS Radisson hotel nearby. The afternoon session started with lectures about all types of osteotomies to address biomechanical problems related to cartilage lesions in the knee. Afterwards live-demonstrations were given by Stefan Nehrer about high tibial osteotomies on saw bones and by me about mini-implants on the femur on the animal model “Miss Piggy”. In the following workshops of the anatomic hall the participants trained again all demonstrated techniques with interest and animated discussions. After this “hard day” we had organized a boat trip along the Warnow to Warnemünde where the river flows in to the Baltic Sea. God listened to my prayers for beautiful weather so we could enjoy the sunset in a summer atmosphere wearing t-shirts and walk on the beach as well as to the lighthouse. At the end of the boat trip we distributed small presents with local specialties to remember the great time spent in Rostock.

After a short night we started the last day with lectures about patella balancing. After my life-demonstration of MPFL-repair on a human cadaver knee, an active discussion was initiated during the demonstration of patient cases. The use of a TED-voting system revealed a high number of correct answers and showed immediately the fast learning-curve of our participants. After final statements by Daniel Saris and me the course ended with the last workshop in the anatomic hall about patella-balancing including trochleaplasty, which was demonstrated by Heinz Bereiter from Switzerland.

I hope that everybody enjoyed the high quality of the science, the live demonstrations, the workshops and the social atmosphere of this complex course of expert didactic lectures and surgical training in Rostock. I want to thank all presenters and our industrial partners for their great efforts and contributions to our course. I also want to thank all participants for the active discussions, the great interest and the warm atmosphere throughout the whole congress. I wish you the best for the future and look forward to seeing you again on our 10th World Congress in Montreal, Canada!

The 1st Congress of the Indian Cartilage Society, New Delhi Deepak Goyal, India - The 1st Congress of the Indian Cartilage Society was held on 12 – 13 November 2011 in New Delhi, organized by Deepak Goyal, who also chairs the Subcommittee for Developing Regions of the ICRS.

The event, attended by 120 participants, was highlighted by a top international ICRS Faculty coming from various corners of the world. Mats Brittberg, Norimasa Nakamura, Asode A Shetty, Prof B H Min, James Hui Hoi Po, Nobuo Adachi, Alberto Restrepo and Deepak Goyal were a few of the prominent international speakers from the ICRS.

The Scientific programme on the 1st day of the Congress consisted of Key Note Lectures, Didactic Lectures, Case presentations, Interactive Discussions etc. The pre-lunch sessions included sessions in “Basic Cartilage Science” and “Cartilage Imaging” as well as “Introduction of micro fracture, OATS and ACI Techniques”, “Chondral lesions in General Orthopaedic Practice” and case discussions. Most of the sessions were planned in such a way that the international faculty members could share their experience and research with the delegates and in the same session also a national faculty presented their work. This combination provided an excellent platform for networking and intense discussions and gave delegates the opportunity to discuss various constraints they face and ways how to overcome them.

Post-lunch sessions included: ‘Present results of various cartilage repair techniques’, ‘Decision making in cartilage lesions of various sizes in different age groups’ and ‘Role of biomechanics in cartilage lesions’. Towards the end, after Nori’s lecture on ‘Results of ACI vs. MTX’ general feelings ran high....

The second day started with a few case reports followed by a live surgery for ‘Assessment of cartilage lesion and cartilage biopsy’. After that; Deepak Goyal operated a case of early medial compartment OA with cartilage lesion. He demonstrated a micro fracture of the lesion followed by a proximal open wedge HTO. An intense discussion was initiated by James Hui Hoi Po who was chairing this session. The last surgery of the day was ‘ACI implantation case’. The biopsy of this case was done six weeks before and cells were just ready for implantation on the day itself. Delegates coming from India were enthusiastic to learn about all these new types of surgery.

The meeting concluded with a special “thank you” to the participants, faculty, sponsors and exhibitors from Deepak Goyal. The next congress shall be held in Chennai in November 2013.
GvO: Who is Kai Mithoefer?

KM: I am currently the co-chairman of the ICRS Sports and Rehabilitation committee and work as an Orthopedic Surgeon with focus on Sports Medicine and Cartilage Repair at Harvard Vanguard Medical Associates, Harvard Medical School in Boston. My clinical and scientific focus is on optimizing the return of the athlete with articular cartilage injury back to sport at the pre-injury level and maintaining the athlete’s ability to play over time.

GvO: Who is Karen Hambly?

KH: I am a UK-based physiotherapist who moved into cartilage repair rehabilitation in 2003 after I struggled to find information on rehabilitation after ACI of the knee. I am currently Co-Chair of the ICRS Sports Injury and Rehabilitation Workgroup. I am a Senior Lecturer within the Centre for Sports Studies at the University of Kent and have recently completed my PhD on the patients’ perspective of outcome measurement after articular cartilage repair of the knee.

GvO: What was, according to you, the most important finding in rehabilitation for cartilage repair the last years?

KM: One of the most important findings in cartilage rehabilitation was the discovery that accelerated rehabilitation can safely introduce low-impact activities early during the postoperative recovery after cartilage repair without compromising the ability to form effective cartilage repair tissue or increasing the complication or failure rate. In fact, this approach has been shown to positively affect joint function and activity levels after cartilage repair.

GvO: Are there regional or cultural differences in rehab?

KM: Through the close communication and availability of information in the media and internet there are few cultural or regional differences in cartilage rehabilitation that I am aware of. Promoting the knowledge and understanding of clinical and scientific advances in this field to the members in all geographic and cultural regions has been one of the primary goals of the ICRS sports rehabilitation committee and is further exemplified with this newsletter.

GvO: How did you appreciate being co-editor of this special issue of the Newsletter?

KM: It is a great opportunity to participate as a co-editor in this important newsletter. It allowed me to help present the ICRS members with a compact and unique overview over the excellent clinical and scientific work that is ongoing in the active field of cartilage rehabilitation. This newsletter will not only be educational but certainly also provide an additional stimulus for continued advances and further communication between ICRS members and researchers in this important field.

GvO: Where and when did you first meet Karen?

KM: I met Karen first when she visited Boston in 2001 and we immediately discovered a similar passion about the field of cartilage health and science. It was the start of a very active and productive collaboration in the area of cartilage rehabilitation and sport that resulted in multiple publications, rehabilitation workshops, formation of the ICRS sports & rehabilitation committee and continues now with this exciting newsletter.

GvO: What, according to you, is the most important issue in rehab for cartilage repair to be solved in the coming years?

KH: There are many unresolved issues in cartilage repair rehabilitation in terms of the content, timing, individualisation, progression and evaluation of the rehabilitation. These issues need to be researched through scientific study and that requires support and funding. Therefore, I see the most important issue being how to encourage and increase the priority for clinical studies on the rehabilitation process rather than the outcomes of different variations of surgical technique and how to gain the funding necessary to make these studies happen.

GvO: Does rehabilitation gets enough attention in ICRS?

KH: I have found the ICRS to be supportive of rehabilitation and the level of attention that rehabilitation gets has increased within the Society but I still don’t think the balance is at the right level as rehabilitation is such an integral part of cartilage repair. In 2004, at the ICRS congress in Gent, there was no formal session on rehabilitation. Now there is a session within most congresses which is a great move forward, but I don’t think a single session in each congress is sufficient to attract the therapists who are responsible for delivering the rehabilitation. The educational opportunities for therapists who are ICRS members are also limited, for instance, therapists are not eligible to apply for many ICRS Fellowship programmes and there is no similar programme available to them within the ICRS. I would like the ICRS to make a serious commitment to motivating therapist involvement in the ICRS so that we can achieve the critical mass needed to move ahead in addressing the issues within cartilage repair rehabilitation. This could take the forms of a satellite meeting at the ICRS congress, a fellowship or scholarship programme aimed at therapists, and research funding specifically for rehabilitation projects. These are my thoughts and personal opinion but do remember I am a therapist myself so I am unreservedly biased!

GvO: How did you appreciate being co-editor of this special issue of the Newsletter?

KH: Co-editing this special issue of the ICRS Newsletter was a great opportunity. We received submissions from four continents covering topics and on reviewing the submissions what struck me was not just the level of interest in cartilage repair rehabilitation but how this interest and the issues we encounter are common across the World.
P.T. is a 49 y old active male who has a remote injury to his knee while playing soccer. He presented for evaluation with an acute increase in his pain after a deep squat. Physical exam revealed loss of motion, a large effusion and medial joint line tenderness. Hip to ankle alignment films revealed 12.5 degree osteotomy was required to correct to between tibial spines. MRI was consistent with a large osteochondral defect of the medial femoral condyle, with a loose fragment in the medial compartment. P.T. was offered arthroscopy to remove loose body, map the osteochondral defect and initiate planning for definitive joint preservation procedure. The patient was offered a bone grafting procedure at the time of his index arthroscopy, but he was unwilling to go through 2 separate procedures with non-weight bearing period of time.

Index Arthroscopy Photos:

- Fig 1. Medial Femoral Condyle Osteochondral Defect with Loose Fragment
- Fig 2. Sizing and depth of Osteochondral Defect After clearing loose fragments

P.T. was asymptomatic for 10 months post-arthroscopy but presented with recurrent effusions and athletic dysfunction. Options for joint preservation were discussed. These included: either Autologous Chondrocyte Implantation (+/- bone graft, depending upon depth) + high tibial osteotomy or Osteochondral Allograft Transplantation + high tibial osteotomy.

The patient chose option 2.

Operative pictures and radiographs:

- Fig 3. Fibrocartilage fill noted 10 months post-arthroscopy
- Fig 4. Completed implantation with Biocompression Fixation
- Fig 5. Demonstration of normal contour restoration of medial femoral condyle
- Fig 6. Immediate post-operative radiographs

Post-operative Course:

Patient was kept non-weight bearing for 8 weeks then progressed to a 3-pont gait until ambulation was pain-free and gait was normalized. A supervised physical therapy program with early ‘gravity-free’ ambulation was instituted. He is currently pain-free.

What would you have done?

Respond to the LinkedIn account and discuss your solution with the group: www.linkedin.com/groups/ICRS or send your comments for the next Newsletter to: office@cartilage.org
**Industry News – Geistlich**

**AMIC Talus – Surgical Technique**

Autologous Matrix Induced Chondrogenesis, AMIC®, is an innovative biological surgical procedure developed by Geistlich Surgery for the treatment of traumatic chondral and osteochondral lesions. This unique single-step procedure combines the microfracturing method, which is an established first-line treatment, with the application of Chondro-Gide®, a porcine collagen type I/III matrix.

The following briefly illustrates the AMIC surgical technique:

**Positioning and Arthroscopy**
AMIC® is performed under a general or spinal anaesthetic in a supine position with a thigh tourniquet. An initial diagnostic arthroscopy can be performed to assess ligament instability and to locate and determine the size of the osteochondral lesions.

**Approach**
Depending on defect location, a mini open ventromedial, central, lateral ventral, dorsomedial or dorsolateral approach is possible. A medial malleolus osteotomy may be required for better access to posteromedial lesions, but can be avoided in most cases through careful distraction.

**Debridement and Microfracturing**
Instable cartilage and cystic lesions are debrided. Microfracturing or drilling of the sclerotic wall with subsequent bone grafting is performed. The cartilage edges of the healthy cartilage must be stable and upright.

**Matrix covering**
The Chondro-Gide® collagen matrix is cut to the size of the defect and using fibrin glue (preferably Tissucol, Baxter), the matrix is subsequently glued directly to the bone reconstruction with the porous surface facing the bone. In order to avoid delamination, care should be taken that the matrix does not overlap the edge of the adjacent cartilage. The stable position of the matrix is checked by moving the joint.

**Correction of the biomechanical factors**
It is recommended that associated pathobiomechanical factors such as instability of the joint or an osseous malalignment are corrected in combination with the AMIC® procedure.

The AMIC® method shows clinically comparable results to autologous chondrocyte implantation and supports the body in the formation of functional cartilaginous repair tissues.

For further information, please contact Geistlich Surgery online or at the ICRS World Congress in Montreal. A full surgical technique video can be viewed on YouTube or on www.geistlich-surgery.com.
BioMatrix™
Cartilage Repair Device (CRD)

Product Features

• Designed to be completely replaced by host cartilage and bone in approximately 18 months
• Biphasic construct, which mimics osteochondral anatomy
• High degree of interconnected porosity, which provides a scaffold for cellular infiltration
• Rapid hydration with autologous blood products like Arthrex ACP® in less than two minutes, ~3% swelling
• Component materials with a long history of clinical use
• Available in 4, 6, 8, 10, 12 and 15 mm
An osteochondral scaffold for cartilage repair based on biological materials

The future of cartilage repair and focal osteochondral defect repair are biological techniques and biological materials. There are a variety of cartilage repair strategies including microfracture, mosaicplasty, scaffolds, and matrices loaded with autologous cells. For osteochondral defects it can be favorable to use biphasic constructs. Besides the biphasic structure the used materials are crucial and have to be selected carefully. There is one cell-free scaffold on the market which consists of two components close to the composition of bone and cartilage and which mimics the osteochondral anatomy. The subchondral region of this so called BioMatrix CRD is made of Tricalciumphosphate and PLA whereas the chondral region consists of bovine Collagen Type I. The high degree of interconnected porosity allows a good integration and cellular infiltration. Remodeling of the matrix proceed parallel to tissue growth.

The caprine study from Ahern et al (1) showed very promising results concerning the remodeling of the scaffold in autologous tissue. A 6 x 6 mm osteochondral defect was created on the medial femoral condyle of the caprine stifle and replaced by the BioMatrix CRD implant. The 18 month histology showed cartilage tissue similar to normal articular cartilage. Type II collagen could be detected in immunohistochemical analysis. Fortier et al (2) evaluate the matrix in an equine model. The 12-month post-operative results suggest an earlier defect fill compared to microfracture. After two years further evaluation will provide quantitative MRI, biomechanical, and biochemical results of this study.

For clinical use the osteochondral defect is removed and replaced by the BioMatrix CRD implant. To accelerate the healing the matrix can be hydrated with platelet-rich plasma (PRP) or autologous conditioned plasma (ACP). Milano et al (3) showed in an experimental study that ACP promoted a reparative response of a cartilage defect until 6 months after treatment. These data indicate that additional ACP injection postoperatively could improve repair mechanism and may support the integration of the matrix. A faster and better healing of the implant may influence the rehabilitation of the patient.


Cartilage publishes articles related to the musculoskeletal system with particular attention to cartilage repair, development, function, degeneration, transplantation, and rehabilitation. The journal is a forum for the exchange of ideas for the many types of researchers and clinicians involved in cartilage biology and repair. A primary objective of Cartilage is to foster the cross-fertilization of the findings between clinical and basic sciences throughout the various disciplines involved in cartilage repair.

The journal publishes full length original manuscripts on all types of cartilage including articular, nasal, auricular, tracheal/bronchial, and intervertebral disc fibrocartilage. Manuscripts on clinical and laboratory research are welcome. Review articles, editorials, and letters are also encouraged. Cartilage is a forum for the exchange of knowledge among clinicians, scientists, patients, and researchers.

Instructions to authors and directions for submissions will be available at http://cart.sagepub.com. Manuscripts can be submitted at http://mc.manuscriptcentral.com/cart.

The International Cartilage Repair Society (ICRS) is dedicated to promotion, encouragement, and distribution of fundamental and applied research of cartilage in order to permit a better knowledge of function and dysfunction of articular cartilage and its repair (www.cartilage.org). Cartilage is published by SAGE on behalf of the ICRS.
Endoret® PRGF®: Technology with a Foundation in Scientific Research

Smith & Nephew is pleased to announce a distribution partnership with Biotechnology Institute (BTI), Vitoria, Spain, for the sale of Endoret PRGF (Plasma Rich in Growth Factors) technology for orthopaedic and sports medicine applications. Endoret PRGF is a system to prepare and deliver autologous growth factors and is based on 15 years of pioneering research by BTI. In recognition of BTI’s contributions in the field of regenerative medicine, Dr. Eduardo Anitua, Scientific Director of BTI, has received numerous awards, including the Prince Felipe Award for Technological Innovation and the Lan Onari prize for contributions to regenerative medicine. The Prince Felipe Award is the most prestigious business award in Spain and BTI was the first medical device company to receive this high honor.

Dr. Anitua, BTI and independent researchers have published over 30 in vitro and in vivo peer-reviewed articles characterizing the effect of PRGF on tissue healing in the field of orthopaedics. PRGF is a leukocyte-poor PRP formulation with approximately twice the platelet concentration of peripheral blood. This concentration was chosen based on numerous studies completed by BTI. In one study, BTI demonstrated that doubling the platelet concentration of PRGF did not improve collagen synthesis or hyaluronic acid secretion. A separate study demonstrated that supplementing PRGF with additional TGF-Beta 1 decreased cell proliferation. These studies indicate that higher platelet concentrations may not further improve healing.

The Utilization of PRGF in Sports Medicine

The first published clinical use of PRP in sports medicine was performed with PRGF. Sanchez et al. used PRGF to supplement articular cartilage healing in the arthroscopic treatment of a large, nontraumatic avulsion. At presentation, a large lesion was located in the medial femoral condyle and another large (>2cm) loose chondral body was detected in the intercondylar fossa area. After debridement and reattachment, the area between the fragment and its bed was filled with approximately 2 ml of liquid PRGF. MRI imaging showed excellent reattachment at 2 weeks after surgery and almost complete congruency after 6 weeks. The patient returned to normal athletic activities after 18 weeks.

The utilization of PRP in sports medicine has garnered interest from both patients and physicians. However, not all PRPs are the same. The differences in platelet concentration and presence of leukocytes are two of the many variables that may influence the efficacy of a PRP-based treatment. While more systematic, clinical studies are needed to further understand the role of PRP in a clinical treatment algorithm, preliminary PRGF research provides a clear rationale for its formulation and its role in enhancing tissue healing and regeneration.

References:
Cartilage Rehabilitation: Global Concepts for Successful Joint Restoration

Editorial / Introduction
Rehabilitation presents a critical component on the path to successful articular cartilage restoration. Its clinical importance is well recognized by the practitioners involved in the care of patients with articular cartilage injury and has been a continued focus of the ICRS.

Since initial cartilage rehabilitation concepts were primarily empirical, the ICRS has been supporting the development of systematic and evidence-based scientific concepts of cartilage rehabilitation. Starting with the first ICRS Rehabilitation Meeting in Zurich in 2007, continued organized efforts included the formation of the ICRS Sports and Rehabilitation Workgroup in 2008 with subsequent publications and regular presentations and rehabilitation sessions at ICRS meetings.

Despite its recognized clinical relevance, scientific knowledge about cartilage rehabilitation is still developing. Cartilage rehabilitation presents a complex field that requires a comprehensive understanding of the biological, biomechanical, anatomical, and surgical technique aspects of cartilage restoration. An improved knowledge of the basic science and clinical details of cartilage rehabilitation will help to improve success. This has been confirmed in several recent studies that demonstrated that cartilage-specific rehabilitation can significantly improve joint function and decrease recovery time after cartilage repair. While these results are encouraging, the rapid development and innovation in the field of cartilage repair demands a similar continued evolution of cartilage rehabilitation.

This newsletter presents a continuation of the ICRS efforts to promote the development of cartilage rehabilitation by facilitating a global exchange of established and developing concepts for cartilage rehabilitation. With a broad spectrum of contributions from 13 countries from 4 continents, the highly active member participation in this rehabilitation newsletter emphasizes the great international focus and scientific relevance of this topic around the world. The newsletter provides a global perspective and overview on ongoing research as well as trends and developments in the field of cartilage rehabilitation. Furthermore, it facilitates international communication between all groups of cartilage researchers and practitioners from different backgrounds. We greatly appreciate the excellent contributions of all the members and hope this ICRS newsletter will help to further stimulate and develop multidisciplinary collaborations to advance knowledge about this critically important aspect of restoring joint function and returning the patient with articular cartilage injury to unrestricted activity.

Kai Mithoefer and Karen Hambly
Co-Chairs, ICRS Sports and Rehabilitation Committee

Part 1 – Reviews
Principles of Rehabilitation after Articular Cartilage Repair in the Athlete
Kai Mithoefer, MD, Stefano Della Villa, MD, Holly Silvers, MPT, Karen Hambly, PhD, Sports and Rehabilitation Committee, International Cartilage Repair Society (ICRS)

Articular cartilage injury is observed with increasing frequency in both elite and amateur athletes and results from the significant acute and chronic joint stress associated with impact sports. Treatment of articular cartilage defects in the athletic population presents a therapeutic challenge due to the high mechanical demands on the joint in the athlete. Several restorative and reparative surgical techniques for articular cartilage repair techniques have shown comparable success rates in restoring articular cartilage surfaces and to return athletes even to high-impact sports. Rehabilitation following cartilage repair surgery presents a critical component in the process of returning the athlete to sports activity. The concepts of current cartilage repair rehabilitation in the athlete are based on a combination of basic science data, empirical information, and limited clinical studies. Returning the athlete to sport can generally be achieved by using the systematic three-phase approach (Table 1). The described principles can be applied to every cartilage repair technique currently available and can be extended to most of the developing new surgical techniques. The progression through the individual phases is determined by the biology of the repair technique, characteristics of the cartilage injury, clinical symptoms, radiographic findings, and individual athlete’s sport-specific demand. The biological phases of each cartilage repair techniques can be matched to the corresponding three rehabilitation phases (Table 1). The biology of the healing process in the first phase is different between restorative (osteochondral auto- and allograft) and reparative techniques (marrow-based and chondrocyte-based techniques). With reparative techniques the early, soft repair tissue is vulnerable to mechanical overload and requires more protection than restorative techniques which rely primarily on bone-to-bone healing. High compressive and shear stresses during the first rehabilitation phase can decrease chondrocyte metabolic rate and should be avoided for both reparative and restorative techniques. However, low mechanical forces promote repair cartilage formation and nutrition as well as bone-to-bone healing and are encouraged. Due to the differences introduced by different cartilage repair techniques, lesion characteristics, and concomitant adjuvant procedures, the initial limit and progression of weight bearing activities should be individually determined by the surgical and rehabilitation teams for each athlete. Consequently, the duration and activities of the protection phase may be variable for each individual athlete. For example, active joint motion may be allowed in the range of motion that is outside of the range of articulation of the repaired defect. Athletes with defects in the patellofemoral joint can weight bear immediately while femoral defects need to be protected. To assure optimal care, the rehabilitation team should be familiar with the surgical and biologic principles that determine the initial protection of the postoperative joint and apply them for each individual athlete’s unique set of circumstances.
Cartilage Rehabilitation: Reviews

Using a criteria-based approach, clinical symptoms are used to individually guide the progress of the athlete through rehabilitation. Pain and particularly joint effusion following the rehabilitation exercise should be avoided as they can lead to quadriceps inhibition with its negative effect on neuromuscular joint control, joint biomechanics and resultant increase in joint reaction force in the area of the cartilage repair. While mild to trace joint effusion is normal during the first 4-6 weeks after articular cartilage repair, extensive efforts should be made to limit and reduce effusion by avoiding overly aggressive rehabilitation. Recurrent joint effusion indicates overload of the repair cartilage and premature progression during rehabilitation and should be avoided.

During the second phase, controlled gradual increase of the mechanical stress on the primary repair tissue stimulates cellular metabolism, proteoglycan and collagen deposition. This strengthens the cartilage repair tissue and makes it more resilient to increasing mechanical stress and more complex joint loading patterns. Restoration of neuromuscular control is critical during the second phase for restoration of joint function and return to athletic activity and should include the entire kinetic chain of the extremity with core, hip, thigh, and calf musculature. Neuromuscular and proprioceptive re-education has important implications for dynamic joint alignment and helps preventing new or re-injury.6,45 Plyometrics effectively restore neuromuscular joint control and optimize joint biomechanics and load distribution under increased impact conditions. Analogous to individualized weight bearing during the initial rehabilitation phase, neuromuscular and proprioceptive exercises should be designed in a gradually progressive fashion to allow for optimal adaptation of the repair cartilage tissue in each patient.

During the final rehabilitation phase further organization and maturation of the cartilage repair tissue occurs by adapting to the even more demanding joint stresses associated with athletic impact and pivoting activities. Adaptations include increased rigidity of the matrix due to further proteoglycan deposition and crosslinking, collagen production and cellular orientation and organization within the neocartilage tissue. Gradually increasing impact and sport-specific movement patterns during this phase prepare the athlete to return to the high mechanical stresses associated with sports without overloading the repair tissue and potential repair tissue deterioration. At this point is not known how the repair tissue quality affects joint function and ability to return to sport. However, prospective data indicates that repair cartilage quantity can affect joint function after cartilage repair as limited repair tissue volume has been associated with a higher failure rate.46 Sport-specific, on-field rehabilitation is a final and critical step in the return to sport after cartilage repair and also follows criteria-based for progression. Before advancing to simulated sports activities, MRI evaluation is recommended to evaluate repair cartilage volume, exclude graft hypertrophy or subchondral bone marrow edema which may indicate risk for graft failure or graft delamination. On-field rehabilitation is organized into gradually increasing sport-specific exercises which progress from in line running and jumping to acceleration and deceleration drills, progressive pivoting and cutting manoeuvres at increasing speeds, and gradual incorporation of sport-specific equipment and movement patterns. Progression is always criteria-based requiring the absence of pain, swelling, and limited ROM with the increasing activity. Using these principles for an individualized approach throughout all rehabilitation phases with close communication between athlete, surgical and rehabilitation staff, return to even demanding high-impact sport and continued sports participation can be successfully achieved with a high rate of success.

Table 1

<table>
<thead>
<tr>
<th>Biologic and Rehabilitation Phases after Articular Cartilage Repair</th>
<th>Phase</th>
<th>Biology</th>
<th>Rehabilitation Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>Graft Integration and Stimulation</td>
<td>Protection and Joint Activation Phase</td>
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<tr>
<td>Phase 2</td>
<td>Matrix Production and Organization</td>
<td>Progressive Loading and Functional Joint Restoration Phase</td>
<td></td>
</tr>
<tr>
<td>Phase 3</td>
<td>Repair Cartilage Maturation and Adaptation</td>
<td>Activity Restoration Phase</td>
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</table>

Knowledge Translation for Articular Cartilage Repair Rehabilitation

Karen Hambly, PT, PhD, United Kingdom

The translation of knowledge to practice has traditionally been a complex and prolonged process. Researchers are primarily knowledge creators but there is also an important role in the translation of this knowledge into practice. The translation of research into practice needs to accelerate to keep pace with rapidly changing fields such as articular cartilage repair. Therapists want to increase their use of evidence but are often inadequately prepared to access, interpret and integrate research findings into their clinical practice.1 There is a need for the synthesis of evidence into accessible formats that can guide clinicians and inform evidence-based practice (EBP).5 The Knowledge to Action Process is a model that ‘funnels’ knowledge derived from research into an action cycle which translates the knowledge into a form to match the unique needs of the user.4 A breakdown or gap in the Knowledge to Action Process results in important knowledge that could be used for the benefit of patients not getting through to practitioners.

Generic rehabilitation protocols and guidelines are frequently used following articular cartilage repair (ACR). However, ACR populations are heterogeneous and in order to optimise post-operative management rehabilitation should reflect the individual context. This requires the rehabilitative team to be familiar with the surgical and biological principles of cartilage repair and to apply them for each individual’s circumstances. Considerations for the individualisation of ACR rehabilitation are often either omitted or are poorly communicated within current generic protocols and guidelines. There is a need for the pragmatic application of research to ACR rehabilitative practice. It is proposed that a clinical decision support system...
KneeGeneration

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NAME OF THE MEDICINAL PRODUCT: ChondroCelect®
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QUALITATIVE AND QUANTITATIVE COMPOSITION: General description: Characterised viable autologous cartilage cells expanded ex vivo expressing specific marker proteins. Qualitative and quantitative composition: Each vial of product contains 4 million autologous human cartilage cells in 0.4 ml cell suspension, corresponding to a concentration of 10,000 cells/microitre.

PHARMACEUTICAL FORM: Implantation suspension. Before re-suspension the cells are settled to the bottom of the container forming an off-white layer and the excipient is a clear colourless liquid. Therapeutic indications: Repair of single symptomatic cartilage defects of the femoral condyle of the knee (International Cartilage Repair Society (ICRS) grade II or IV) in adults. Concomitant asymptomatic cartilage lesions (ICRS grade I or II) might be present. Demonstration of efficacy is based on a randomised controlled trial evaluating the efficacy of ChondroCelect® in patients with lesions between 1-5cm².

Posology and method of administration: ChondroCelect® must be administered by an appropriately qualified surgeon and is restricted to hospital use only. ChondroCelect® is solely intended for autologous use and should be administered in conjunction with debridement (preparation of the defect bed), a physical seal of the lesion (placement of a biological membrane, preferentially a collagen membrane) and rehabilitation. Posology: The amount of cells to be administered is dependent on the size (surface in cm²) of the cartilage defect. Each product contains an individual treatment dose with sufficient number of cells to treat the pre-defined lesion size, as measured at biopsy procurement. The recommended dose of ChondroCelect® is 0.8 to 1 million cells/cm², corresponding with 80 to 100 microitre of product/cm² of defect. Method of administration: ChondroCelect® is intended solely for use in autologous cartilage repair and is administered to patients in an Autologous Chondrocyte Implantation procedure (ACI). The implantation should be followed by an appropriate rehabilitation schedule for approximately one year, as recommended by the physician. Contraindications: Hypersensitivity to any of the excipients or to bovine serum. ChondroCelect® must not be used in case of advanced osteoarthritis of the knee.

Undesirable effects: In a randomised, controlled study in the target population, 0 (0%) patients were treated with ChondroCelect®. In these patients, a periosteal flap was used to secure the implant. Adverse reactions occurred in 78.4% of the patients over a 36-months postoperative follow-up period. The most common adverse reactions were arthralgia (47.1%), cartilage hypertrophy (27.4%), joint crepitation (17.6%) and joint swelling (13.7%). Adverse reactions collected from 370 patients included in a Compassionate Use Program are similar to those reported in the target population. Most of the reported adverse reactions were expected as related to the open-knee surgical procedure. The most frequently occurring reactions reported immediately after surgery include joint swelling, arthralgia and pyrexia. These were generally mild and disappeared in the weeks following surgery. Adverse reactions of special interest: Arthrotrophy: In the compassionate use patients, a higher incidence of arthrotrophy and decreased joint range of motion was observed in a subgroup of patients with a patellar lesion (6.2%) and 11.1%, respectively) compared to non-patellar lesions (0.6% and 2.6% respectively). Cartilage hypertrophy: In the majority of the 370 patients included in the Compassionate Use Program, a collagen membrane instead of a periosteal flap was used to seal the defect.
Therapeutic indications:

The product contains an individual treatment dose with sufficient number of characterised viable autologous cartilage cells to treat the pre-defined lesion size, as measured at biopsy (10,000 cells/microlitre implantation suspension).

Characterised viable autologous cartilage cells expressing specific marker proteins.

ChondroCelect®  is a medicinal product and is currently available and authorised for use in the European Economic Area

ChondroCelect® is subject to restricted prescription. Please refer to the prescribing information below.

According to current literature the incidence of cartilage hypertrophy can be reduced by using a collagen membrane to cover the lesion site instead of using a periosteal flap (Koeding et al., 2006; Niemeyer et al., 2008). When a collagen membrane was used to seal the lesion site after application of ChondroCelect®, the incidence of cartilage hypertrophy was reported to be 1.8% compared to 25% in the randomised, controlled trial alone.

**Name of the MA holder:** TiGenix NV, Romeinse straat 12/2, B-3001 LEUVEN, Belgium.

**Market authorisation number:** EU/1/09/563/001. Medicinal product to restricted medical prescription – restricted to hospital use only.

2. TiGenix data on file.

**Undesirable effects:**

- Cartilage hypertrophy: According to current literature the incidence of cartilage hypertrophy can be reduced by using a collagen membrane to cover the lesion site instead of using a periosteal flap (Koeding et al., 2006; Niemeyer et al., 2008). When a collagen membrane was used to seal the lesion site after application of ChondroCelect®, the incidence of cartilage hypertrophy was reported to be 1.8% compared to 25% in the randomised, controlled trial alone.

- Arthrofibrosis: In a randomised, controlled study in the Compassionate Use Program, a collagen membrane instead of a periosteal flap was used to seal the defect. In these patients, a periosteal flap was used to secure the implant. Adverse reactions occurred in 78.4% of the patients in the Compassionate Use Program, 67.9% of the patients in the randomised, controlled trial alone.

- Hypertrophy (27.4%), joint crepitation (17.6%) and joint swelling (13.1%) compared to non-patellar lesions (10.5%, 22.9%, 17.6% respectively) and 12.3%, 19.9%, 15.3% respectively) compared to patellar lesions (8.2%, 17.6%, 13.1% respectively).

**Common adverse reactions were arthralgia (47.1%), cartilage hypertrophy (27.4%), joint crepitation (17.6%) and joint swelling (13.1%) in a subset of patients with a patellar lesion (8.2%, 17.6%, 13.1% respectively) compared to non-patellar lesions (10.5%, 22.9%, 17.6% respectively).**

**Results in Better Structural Repair when Treating Symptomatic Cartilage Defects of the Knee in a Randomized Controlled Trial versus Microfracture**

According to current literature the incidence of cartilage hypertrophy can be reduced by using a collagen membrane to cover the lesion site instead of using a periosteal flap (Koeding et al., 2006; Niemeyer et al., 2008). When a collagen membrane was used to seal the lesion site after application of ChondroCelect®, the incidence of cartilage hypertrophy was reported to be 1.8% compared to 25% in the randomised, controlled trial alone.
Cartilage Rehabilitation: Reviews

(CDSS) that provides easily accessible and current information on the considerations for ACR rehabilitation will overcome some of the barriers to EBP (see Figure 1). The goal is to create a simple knowledge-based system that can facilitate clinician learning and guide practice for the benefit of the patient whilst complementing, rather than supplanting, existing generic rehabilitation protocols.

Figure 1: Overview of the inputs and outputs of a clinical decision support system.

A CDSS is being developed by the University of Kent in the UK utilising three components integral to the Knowledge to Action Process – the knowledge base, the inference engine and the communication mechanism. The knowledge base embedded in the CDSS was derived from published literature. A heuristic approach was adopted for the inference engine with the input of individual patient data triggering specific guidance based on rules constructed from the knowledge base (data-directed inference). Heuristics provide guidelines and problem-solving strategies that permit more individual variation than an algorithmic approach where a rigid sequence of ordered steps results in a list of instructions for a solution. Clinicians are autonomous professionals and as such should be allowed to determine the relevance of the research to their individual clients.

Problems are frequently not clearly defined in rehabilitation so it was considered important to knowledge translation that the clinician is presented with considerations for how they may wish to individualise rehabilitation rather than specific rigid instructions. The communication mechanism was developed to deliver these rehabilitation considerations in an accessible format that provides the opportunity for the clinician to further evaluate the evidence-base underpinning each of the considerations.

Review of the evidence-base resulted in the identification of eleven primary factors implicated in the ACR rehabilitation process. A branch logic approach produced a multi-level hierarchy with each primary factor having a branched pathway. The number of logic pathways meant it was not conducive to hard copy format and resulted in the selection of a web-based format on a dedicated website www.cartilagerehabilitation.info. An expert system shell has been identified and an iterative design cycle of testing, consultation and refinement will take place prior to the launch of CDSS as an “on demand” system in summer 2012. The development of this CDSS, as with any decision aid, presents considerable opportunities but also many challenges.

There is the assumption that the integration of research into EBP will result in improved patient outcomes and this still needs to be established with respect to articular cartilage repair. Future studies will evaluate the access to and use of the CDSS and to assess changes in practice.

References:

Part 2 – Basic Science Application to Rehabilitation

Rehabilitation – in vitro investigations at the cellular level

Sibylle Grad, Mauro Alini, Martin J. Stoddart, AO Research Institute Davos, Switzerland – Martin.stoddart@aofoundation.org

There have been numerous studies focusing on the use of mesenchymal stem cells (MSCs) for the repair of acute cartilage defects. Most follow the structure of classical tissue engineering, investigating implant properties at the biochemical level, or structure/function in in vivo studies. In comparison, relatively few studies have investigated the role of biomechanics on stem cell fate decisions. When considering the clinical situation it is likely the rehabilitation protocol, and hence biomechanical stimulus applied, after cellular implantation will influence the final outcome. Studies investigating mechanical regulation have focused mainly on hydrostatic[6, 7] and uniaxial compression[8, 9] and multiaxial (shear and compression) loading[8, 9]. To more accurately mimic the in vivo environment it is likely that complex multiaxial loading will be required. Using a custom built bioreactor[9] which is able to apply compression, shear or a combination of the two (Figure 1) we have been investigating the role of the individual stimuli and the combination of the two on fibrin-polyurethane constructs seeded with human bone marrow derived stromal cells[10]. Within this system we are able to simulate a more natural kinematic environment using clinically relevant cells within a hydrogel familiar to orthopaedic surgeons (fibrin).

We have recently shown that shear appears to be a critical requirement for mechanically induced chondrogenesis of
Cartilage Rehabilitation: Basic Science Application to Rehabilitation

Use of such a device enables controlled in vitro studies to investigate duration, frequency, amplitude and the timing of initiation and the load applied. This would include whether an initial period of shear alone, as applied during continuous passive motion, is beneficial at the cellular level when compared to early application of both shear and compression, as experienced during partial load bearing. Moreover, the impact of specific biochemical supplements during regeneration can be determined in a controlled biomechanical environment. Due to the compliance issues these studies are difficult to perform in vivo and due to immunological issues any in vivo study would likely use animal cells and not those from adult humans. We hope this system can provide a valuable insight into potential rehabilitation protocols and that information gained can be translated into a clinical setting.

References:

CPM or not CPM after autologous chondrocyte transplantation?

Guo Quanyi, Lu Shibi, Yu Changlong, Key Laboratory of the People’s Liberation Army (PLA), Institute of Orthopedics, Chinese PLA General Hospital, China, E-mail address: doctorguo@163.com, ycl123@vip.sina.com

So far, autologous chondrocyte transplantation (ACT) has been employed widely in many countries for the treatment of large size articular cartilage defects. Several disputes still exist; one is the cells quantity versus how to keep the cells phenotype in culture condition for a quite long period. In general, the shorter in culture, the better cells phenotype. Some centers expand chondrocytes in large quantity, and then the cells will be under the dedifferentiation condition, it is hardly believed such cells will be different among chondrocytes after transplantation in vivo. The second is culture medium; to avoid using fetal calf serum is

Figure 1: Schematic representation of the forces applied through the knee joint (left). The bioreactor used during these studies is able to apply similar multiaxial forces (right).

Figure 2: Bovine chondrocytes were seeded into a fibrin/polyurethane scaffold and cultured under various conditions for 3 weeks. Free-swelling controls (A) did not display any staining for lubricin. Samples exposed to compression alone also were negative for lubricin (B). However, samples cultured with shear, superimposed on compression, displayed intense lubricin staining at the surface of the construct.

The influence of different modes of mechanical load has been investigated not only with respect to MSC differentiation; several studies have shown stimulating effects on articular chondrocytes seeded into 3D scaffold systems. Results from these studies may have implications for optimizing physical therapy concepts after chondrocyte transplantation treatments. For example, different studies have revealed that application of dynamic shear to the surface of chondrocytes-seeded scaffolds up-regulates the gene and protein expression of the cartilage superficial zone protein (Figure 2), which is also known as lubricin or proteoglycan-4 (9, 10). Lubricin is an important component of normal synovial fluid which is specifically expressed at the articular surface, and has a major role for maintaining low friction joint articulation. Looking at different motion paths and loading frequencies, it was found that both the type of motion, such as flexion, rotation, or translation, and the sliding velocity affected the cellular response (9). Furthermore, it was shown that not only articular but also nasal chondrocytes were responsive to specific loading patterns that simulate joint articulation (9). Hence it is possible to test the reaction of cells from different sources, embedded in suitable biomaterial matrices, under addition of anabolic factors if requested, to relevant mechanical forces.

While the device is not a complete reproduction of the in vivo environment, it can offer insights into the role of various biomechanical stimuli on stem cell fate decisions, (re-)differentiation of chondrocytes, and cartilaginous tissue development. In a previous study we had shown that the chondrogenic response is modulated by the frequency and amplitude of the multiaxial load applied, suggesting that this model can be used to pre-screen rehabilitation protocols (5). Within this system, the application of multiaxial load leads to endogenous production of TGF-β which then leads to the chondrogenic induction (5).

human MSCs within this system. In agreement with other studies, compression alone did not induce chondrogenesis, however shear superimposed on compression lead to a more robust chondrogenic response (10). As the study did not include exogenous TGF-β, any chondrogenic induction was as a result of the mechanical stimulation applied. This would suggest that mechanical stimulation alone is able to direct human MSCs towards a chondrogenic phenotype. In a previous study we had shown that the chondrogenic response is modulated by the frequency and amplitude of the multiaxial load applied, suggesting that this model can be used to pre-screen rehabilitation protocols in vitro (5). Within this system, the application of multiaxial load leads to endogenous production of TGF-β which then leads to the chondrogenic induction (5).
Cartilage Rehabilitation: Basic Science Application to Rehabilitation

Scaffold is the most important element for successful transplantation; the communication between cells and matrix plays the key role for the property of new forming tissue. Unfortunately, there are very limited choices for scaffold for ACT. In the early stage periosteum was the only option of scaffold, in recent years a collagen membrane consisting of collagen type I and III replaced periosteum as the scaffold. Cultured chondrocytes are either injected underneath the scaffold which is sutured on the defect area first or loaded on the scaffold then glued on the defect. All the scaffolds mentioned above do not resemble real articular cartilage either in composition or structure. Collagen type I and III do not exist in normal articular cartilage and the arrangement of these collagen fibers does not behave like real hyaline cartilage as well. Chondrocytes grow on such structures, but lack normal communication between cells and matrix, and it is impossible to harvest real hyaline cartilage after transplantation.

We are using our own scaffold with two characteristics, the scaffold is made by the matrix of human articular cartilage, the most of the composition of scaffold is collagen type II and proteoglycans. On top of it, the scaffold preserves hyaline cartilage structure and the collagen fibers and proteoglycans are directionally arranged as perpendicular columns to resist pressure more effectively.

Continuous passive motion (CPM) is a useful tool for rehabilitation after joint surgery. However, for cartilage transplantation, different centers use different protocols, some report good outcomes after using CPM, but some have had negative experiences. We have used CPM in our rehabilitation protocol routinely for ACT patients after our animal experimental study. A special designed CPM was used for goat knee joint after ACT (fig 1-2). The results of the CPM protocol were superior to the no CPM protocol. Then we started using CPM for our patients who had undergone ACT. The clinical outcome also showed a benefit in using CPM.

For the first week of CPM, the purpose is to let the patient adapt to the treatment and give slight pressure on the transplanted tissue. The loading pressure is applied to the defect area gradually by control of the moving angle of the knee joint. If the repair area is between the patella and femoral trochlea, the moving angle should be controlled from 0-30 degrees for the first 7 days, and then the angle increases 5 degrees every 2 days until the range reaches 0-90 degrees. The 0-90 degree moving range should continue until the end of 8th week. If the defect area is in femoral condyle, the starting angle should be from 0-45 degrees for the first 7 days, and then the angle also increases 5 degrees every 2 days until the range reaches 0-110 degrees. The 0-110 degrees moving range should continue until the end of 8th weeks as well.

According to our experience, CPM should be applied at least 1 hour each time, 2 times per day will be adequate. After CPM, an ice pack should be put on the joint for 30 minutes. CPM for our patients with autologous chondrocytes transplantation has a good outcome and we recommend it for the rehabilitation. Adequate pressure applied gradually on the defect is necessary.

Part 3 – Clinical Experiences
Challenging but necessary standardization of rehabilitation during cartilage repair clinical trials
Matthew Shive, PhD, Clinical Science Consultant, Canada

Current orthopaedic efforts towards improving evidence-based treatment algorithms in cartilage repair should also recognize post-treatment rehabilitation as a critical covariate in the analysis and understanding of outcome success. At the same time, manuscript reviewers and regulatory agencies are expecting to see standardized rehabilitation data in their submissions. However, the standardization and control of patient rehabilitation offers unique challenges, particularly in multicenter studies of large or varied geographic scale, and even more so for those intended to meet regulatory requirements and conducted under GCPs.

The first challenge is represented by the rehabilitation protocol itself. Unfortunately, rehabilitation has not been well-studied in the context of cartilage repair, and in some cases orthopaedic surgeons have developed their own preferred programs with little or no scientific basis, or patients are relegated to follow programs established by the therapist themselves. Therefore, the design of new cartilage repair studies should carefully weigh the choice of rehabilitation protocols, their implementation and the type of data that will be collected. Study protocols should dictate the selection of the appropriate therapeutic modalities and post-operative timeframe, such as the period of restricted weight bearing, or the use of continuous passive motion (CPM). Furthermore, clinical trials which compare cartilage repair therapies that differ in their repair mechanisms- as with an osteochondral graft device and microfracture- might call for different protocols altogether.

Choosing specific rehabilitation parameters and the extent of data collection can represent an excellent, albeit challenging, opportunity to understand how a rehabilitation protocol influences repair outcomes. Even simple variables like patient compliance, the progression of ROM and weight bearing and physical knee characteristics could be informa-

Fig 1: CPM leads goat knee flexion.  Fig 2: CPM leads goat knee extension. (From the front)
Cartilage Rehabilitation: Clinical Experiences

tive, as well as more complex data obtained from functional tests of gait or proprioception. The extent of the data and the method of collection should be established with the therapists prior to treatment. Electronic data capture facilitates this collection and permits real-time tracking of both therapists and progression of patients. On the other hand, special consideration should be made as to the role that rehabilitation plays within a study protocol and its relationship to study endpoints. Regulatory requirements have not been clear regarding the level of statistical analysis and correlation to treatment outcomes which must be carried out. This issue needs to be clarified at an agency level; particularly if poor rehabilitation compliance or progression is viewed as a study protocol deviation with direct consequences on final endpoint statistical analyses.

Selection and training of therapists is also an essential step in successfully implementing a standardized rehabilitation program. International studies offer the challenge of multiple languages and may need to employ therapists with differing educational backgrounds but who have appropriate experience. Direct training and communication with all therapists is critical, especially with regards to study treatment, lesion size and location or other unique study components. Furthermore, the logistics and financial management, if needed, of such a relationship with the clinic or hospital providing the rehabilitation service, needs to be well established in advance of patient treatment.

Patients should be well informed regarding the importance of protocol compliance (e.g. attending sessions, weight bearing requirements) to both the health of their knee as well as the clinical study. Encouragement should not only come from the clinical site and the investigator, but also from the participating therapists. The objective of an unbiased study rehabilitation program should try to avoid the situation where compliance becomes a function of the efficacy of treatment, or of the willingness or ability to pay.

The energy and resources needed to overcome the intrinsic challenges of a well thought-out and implemented rehabilitation program with experienced therapists will certainly serve to normalize cartilage repair outcome data, while at the same time focusing much needed attention on the specific rehabilitation modalities currently used but for which there is little scientific evidence. Concurrently, such a program in clinical trials supporting regulatory submissions will meet the expectations for management and tracking of post-treatment care. Consequently, cartilage repair patients will benefit from rehabilitation protocols with valid scientific basis.

Clinical, radiological and biomechanical outcomes of a randomized comparison of conservative and accelerated approaches to post-operative weight bearing rehabilitation following MACI®

While surgical and cell culturing methods with respect to autologous chondrocyte implantation (ACI) have improved over the past 10 years, it is well known that research into post-operative rehabilitation, an important component for achieving optimal surgical outcome, is still in its infancy. At present, best patient outcome appears limited by a lack of knowledge regarding how to progressively increase weight bearing (WB) and exercise post-surgery. This research project sought to ascertain the impact of accelerated WB rehabilitation, compared with a more conservative WB approach, in patients following MACI implant. Recruitment for the project spanned two years from 2005-2007, culminating in several scientific publications, as well as documented rehabilitation protocols published in collaboration with Genzyme.

A randomized controlled study design was used to investigate clinical, radiological and biomechanical (gait) outcomes in 70 patients following MACI implant, in conjunction with either ‘accelerated’ or ‘conservative’ approaches to post-operative WB rehabilitation. Both interventions sought to protect the implant for an initial period, and then incrementally increase WB. Under the ‘accelerated’ protocol, patients reached full WB at 8 weeks post-surgery, compared to 11 weeks for the ‘conservative’ group (Table I). Outcomes have been undertaken thus far pre-surgery and at 3, 6, 12 and 24 months post-surgery.

Patients in the ‘accelerated’ group demonstrated significantly greater (p<0.05) six minute walk distances and daily activity levels, as well as a significantly better (p<0.05) improvement in knee pain, when compared to the ‘conservative’ group at 3 months post-surgery. While both patient groups improved significantly to 24 months post-surgery, the accelerated group reported significantly less severe pain (Figure 1) and demonstrated superior six-minute walk distances (Figure 2) over the two-year period.

TABLE 1: The load bearing gradients followed by MACI patients in the traditional and accelerated rehabilitation groups.

<table>
<thead>
<tr>
<th>Conservative Group</th>
<th>Weeks Post-surgery</th>
<th>2</th>
<th>3</th>
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continued next page...
With regard to radiological outcomes, regardless of the rehabilitation protocol employed, no patient suffered any adverse effect to the implant as assessed by magnetic resonance imaging (MRI) at three months, indicating graft tolerability to the faster return to full WB. Both groups significantly improved (p < 0.05) in an MRI composite score and pertinent descriptors of graft repair throughout the post-operative period, up until 24 months post-surgery. There were no differences (p > 0.05) observed between the two groups. However, patient age, body mass index, defect size and the duration of pre-operative symptoms were all significantly correlated (p < 0.05) with several MRI-based outcomes at 24 months.

Three-dimensional gait analyses at 3, 6 and 12 months post-surgery demonstrated significantly reduced (p < 0.05) knee extension moments in both patient groups up to, and including, 12 months, when compared with control subjects. However, while the conservative WB group demonstrated significantly reduced (p < 0.05) knee adduction moments at 3, 6 and 12 months, and a significantly reduced knee flexion moment at 3 months, no differences in these knee moments were observed between the accelerated patient group and controls. Overall, a higher level of gait dysfunction was observed in patients who underwent a more conservative rehabilitation approach. These gait analyses also provided insight into the variables (in addition to ground reaction forces) that contribute to these knee moments, which has improved the accuracy in prescribing and implementing progressive WB protocols for MACI implant patients.

Overall, the ‘accelerated’ WB approach that reduced the length of time spent ambulating on crutches produced comparable, if not superior clinical outcomes up to 24 months post-surgery in the accelerated rehabilitation group, without compromising graft integrity. This ‘accelerated’ regime is safe, effective and demonstrates a faster return to normal function post-surgery, and may reduce post-operative muscle loss, intra-articular adhesions and associated gait abnormalities.

This project has been undertaken in association with the University of Western Australia (School of Sport Science, Exercise and Health and the School of Surgery) and the Hollywood Functional Rehabilitation Clinic. We are now nearing completion of assessment at five years post-surgery and, based on the encouraging outcomes thus far, have initiated a new trial, part funded by a National Health and Medical Research Grant (APP1003452). This trial aims to compare our current ‘best-practice’ WB approach (8 weeks) with a further accelerated gradient of 6 weeks, in patients following both open and arthroscopically performed MACI implant to the WB femoral condyles and tibial plateau. The ‘Accelerated Rehabilitation Guidelines for the Knee Using MACI’, and associated ‘Exercise Companion Guide’, can be obtained through requests to your local Genzyme representative or by filling out the contact form at www.maci.com/contact.aspx.

References:
Cartilage Rehabilitation: Clinical Experiences

Progressive Joint Loading after Cartilage Repair with Autologous Matrix-Induced Chondrogenesis (AMIC) with Platelet Rich Plasma (PRP) Augmentation: Clinical Experience in 220 Patients  Alberto Sciliari, Italy

Rehabilitation after articular cartilage surgery is widely recognized as critical to long-term outcome but the use of new techniques, like Autologous Matrix-Induced Chondrogenesis (AMIC), have simplified this part of the treatment. In my experience of 220 procedures I have used AMIC with a scaffold (Chondrotissue®) and PRP as glue and source of growth factors.

With this technique the patient is discharged after a few hours and encouraged to move the knee immediately following a specific rehabilitation protocol after the procedure. The first rehabilitation phase, which lasts two weeks, starts 6 hours after surgery with active motion exercises. The surgical procedure is entirely done arthroscopically so the post-operative pain is minimized and continuous passive movement is not necessary.

The patient is encouraged to actively move the knee and to use some simple static quadriceps exercises. The only limitation is that of movement which is post-operative pain, which is usually minor, and joint effusion. In this first phase no weight bearing is permitted to protect the matrix from tangential forces that may injure the implant. In this period, the highly hydrophilic scaffold (Chondrotissue®) allows for circumferential layer lubrication that helps the PRP–glue to maintain the implant in place. Lane (4) has observed a dramatic increase in the cartilage coefficient of friction (COF) that can potentially damage chondrocytes when the patient begins articulating the joint after surgery. Such injuries may affect the ability of the repair cartilage to heal fully.

Reducing the elevated COF with lubricating materials is recommended. After two weeks, in the second phase, the patient is allowed to walk with crutches using partial weight bearing for one week. This period is necessary to recovery a correct gait pattern and to permit initiation of hydrodynamic lubrication, so-called because the dynamic motion of the weight bearing areas produces an aqueous layer that separates and protects the contact points. This kind of lubrication physiologically occurs with load of cartilage and the cyclical loading is probably useful for an effective growth of the new cartilage tissue.

Papachristou (2) demonstrated that functional cartilage loading induces the AP-1 and Runx2 transcription factors through the JNK and ERK MAPK cascades. Since the above signaling mediators/effectors are considered to be crucial in the differentiation/maturation process of cartilage tissue, Papachristou suggests that functional mechanical loading of condylar cartilage serves to “fine tune” chondroblastic differentiation/maturation. Saadat (3) concludes that cyclical in vivo joint loading increases the proteoglycan content of the cartilage deep zone via signal transduction stimulated by increased hydrostatic pressure. This is clinically significant because the biomechanical properties of cartilage, and therefore its function, depend to a large extent on its ability to maintain hydration and tissue thickness under mechanical stresses with normal physiological loading. Proteoglycans provide the osmotic resistance necessary for cartilage to resist compressive loads. Kupcsik (4) observed that mechanotransduction of mesenchymal stem cells in a three dimensional scaffold increases synthesis of sulfated glycosaminoglycans (GAGs). Bian (5) demonstrated that dynamic mechanical loading enhances functional properties of tissue-engineered cartilage using mature canine chondrocytes. Hardmeier (6) concluded that mechanical stress is associated with cellular signalling communication and the preservation of N-terminus procollagen moieties, which regulate both collagen synthesis and the diameter of the fibre. This structural difference also affects actin stabilization, cytoskeleton remodelling and proteoglycan assembly. These effects seemed to be dependent on the magnitude and duration of the physical stress.

All these experimental studies enforce the idea that an early load is favourable for cartilage healing. After the partial weight-bearing period, the load is increased up to normal weight bearing and the patient is encouraged to start gentle swimming and cycling exercises. Complete weight bearing is reached at 4 weeks after surgery. Complete recovery of functional daily activities begins usually after 6 weeks.

References:
Saadat E.et al. Long-term cyclical in vivo loading increases cartilage proteoglycan content in a spatially specific manner: an infrared microspectroscopic imaging and polarized light microscopy study Arthritis Research & Therapy 2006, 8: (5):R147

Customised postoperative therapy has a crucial impact on the outcome of cartilage surgery  Eric Reiss, MD and Catherine Kessler-Schär, Graduate Physiotherapist, Orthopraxis Oftringen, Switzerland

To what extent can the rehabilitation process be optimised through customised adjustments of postoperative therapy? What impacts do “touch qualities” such as patient guidance have? What is the surgeon’s role in postoperative therapy? To answer some of those questions, we have started to analyse adjustments in postoperative care and their impact on outcome in our clinic and would like to share with you first results.
So far, we analysed a total of 28 patients (average age 38 years) who underwent cartilage repair surgery and postoperative therapy in-house, all with a sports background. Their femorotibial and/or femoropatellar cartilage defects (> 2 cm²) were treated with the AMIC® surgical procedure. The Autologous Matrix Induced Chondrogenesis (AMIC®) is a single step procedure based on micro fracturing in combination with ChondroGide®, a bilayer collagen matrix. In all cases, the indication and contraindication criteria were invariably observed.

In 16 of the 28 patients, simultaneous valgisation, varisation or cruciate ligament surgery was performed to correct axis, instabilities and accompanying pathologies.

The surgical procedures were performed by the same team of surgeons and subsequently all patients received postoperative therapy supervised by the same physiotherapists. During the postoperative phase, the surgeon and the physiotherapists formed a team, continuously assessing the joint in order to allow adaptation to the therapy.

Data were collected using the Geistlich Registry. This internet-based database allows recording and analysis of clinical results including medical history, clinical diagnosis, the Lysholm knee score, VAS pain scale and MRT analysis. We additionally monitored the progressive pain reduction, strength development and the increase in mobility utilising a goniometer. Thorough analysis of all data allowed correlating combination procedures, location, size and depth of the defect with postoperative criteria such as edema, tendency to swelling, pain and improvement of mobility.

At the start of the observation process, the team applied the post-operative guidelines recommended by Geistlich Pharma AG for “AMIC® Knee patients”. We then modified these on the basis of the gained experience. As a result, the postoperative therapy focused increasingly on soft tissue techniques such as freedom of movement rather than on developing strength and coordination.

Based on our observations, we developed an adapted “4-Phase Model” (see Table 1), which has now become an established standard at our clinic.

### Table 1: 4-Phase Model. The focus of treatment changes over the course of the rehabilitation

<table>
<thead>
<tr>
<th>Phase 1: Inflammatory phase</th>
<th>Week 1–2</th>
<th>Swelling/pain/metabolism Limitation of flexion in most cases 30°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 2: Remodelling phase</td>
<td>Week 3–4</td>
<td>Proprioception/isometry/ TENS/active motion splint at home (e.g. CAMOped)/Progressive weight bearing Flexion limitation 60°</td>
</tr>
<tr>
<td>Phase 3: Load progression</td>
<td>Week 7 – 3rd month</td>
<td>Full load/two-leg stance without retropatellar pressure/ diversified ground surfaces /ergometer/gait therapy/ strength (closed chain) Flexion limitation 90°</td>
</tr>
<tr>
<td>Phase 4: Back to life</td>
<td>From 4th month</td>
<td>Build-up of resistance on leg press/squats/ sport-specific training Free range of motion</td>
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</tbody>
</table>

Our experience confirms the fact that rehabilitation of patients with retropatellar and femoral trochlea cartilage defects is more complex than of patients with femorotibial defect locations. While patients with retropatellar and femoral trochlea defects presented pain syndromes of longer duration and tendency to swelling up to 3 months after surgery, a rapid increase of mobility and decrease of pain was observed in those with femorotibial defects. It was also detected, that coordination and isometry were decreased in patients with retropatellar defects. In this group a marked hypotrophy of the femoral quadriceps muscle measuring up to 4 cm was visible during the 3 months follow-up.

The most rapid rehabilitation and best results in terms of pain, tendency to swelling, VAS pain scale as well as return to the former level of sports was achieved by the patients in whom an indicated simultaneous tibial valgisation osteotomy was performed.

Despite the low number of cases investigated, we are convinced that close cooperation between the surgeon, the physiotherapist and the patient during rehabilitation has a crucial impact on the quality of the cartilage repair. It is only with the help of such holistic and accompanying postoperative therapy that the healing process can be optimally adapted not only to the specific clinical situation, but also to the patients’ requirements for optimal results. Since almost no evidence-based data are available on this topic, we would like to encourage the cartilage community to investigate this further.
ACL Reconstruction with concomitant Actifit meniscus implant as a prevention of cartilage damage

Emilia Kurowska, Maciej Piatkowski, Konrad Slynarski, Sports Medicine Center CMS Warsaw, Poland

The literature is showing more and more studies documenting meniscus implants with the use of scaffold, however, the rehabilitation process has not been documented yet (in particular with concomitant ACL reconstruction). In such cases it is believed that the future results of ACL reconstruction rely on the meniscus treatment.

Damage to the avascular part of the meniscus is of significant importance due to the low ability to recover. Hence, meniscectomies were a gold standard when treating damages of such size. Menisci are of fundamental importance in the knee joint, thus, a partial or total meniscectomy may lead to irreversible degenerative arthritis and, as a consequence, to damage the joint. Taking a longer perspective it can result in varus knee as well as significant overload and degeneration of the articular cartilage. ACL reconstruction only improves the stability of knee joint and does not solve the problem regarding the joint surfaces. Actifit is a biodegradable meniscal implant. It is a porous scaffold made of aliphatic polyurethane providing optimal mechanical strength, biocompatibility and safe degradation (Fig.1). The blood transports cartilage repair cells and other nutrients that initiate the growth of new meniscus-like tissue. We believe that patients would benefit from a concomitant ACL reconstruction with arthroscopic medial meniscus repair and such a procedure will act as prevention from cartilage damage.

The study includes cases of 10 patients after ACL reconstruction with a concomitant arthroscopic medial meniscus repair with the use of a polyurethane implant (Actifit). In order to protect both the ACL, implant and the new fragile cartilage tissue the patients undergo a conservative rehabilitation process. Protecting the meniscus implant is of particular importance, thus, the rehabilitation programme is delayed compared with rehabilitation after an isolated ACL reconstruction. It focuses mainly on the range of motion (ROM), weight bearing status and, consequently, recovery to daily life activities and sports (Fig.2). Both level of pain and swelling need to be under constant control.

Patient compliance with activity modification, weight-bearing status, cryotherapy and therapeutic home exercises programme is emphasized. The rehabilitation programme begins immediately after surgery, to achieve full extension. Loss of extension following surgery can result in an abnormal gait, increased patellofemoral symptoms and quadriceps weakness. Patellar mobilization should be performed by the therapist to assist in reestablishing normal patellar mobility. If a patient has a deficiency in quadriceps contraction, a biofeedback unit or electrical stimulation can be used in conjunction with quadriceps setting exercises to improve facilitation of the quadriceps reeducation. A straight leg raise (SLR) is performed with the postoperative brace locked at 0 degrees until not only a sufficient quadriceps control is reached, but also the person is able to perform the SLR without pain or quadriceps lag. Range of motion, weight-bearing status and exercises are adapted individually to the patient’s condition. Patients had 3–5 rehabilitation sessions per week with a single session lasting for 2 hours and a total duration of rehabilitation of 6 months.

Patients were evaluated with KOOS score, but their individual opinion was also taken into consideration. The patients were reported to significantly recover in terms of pain during a 12-month observation. They were assessed preoperatively and postoperatively, after 3, 6 and 12 months respectively. The outcomes of the KOOS score for pain have improved significantly from 62 preoperatively to 90 postoperatively. Their activities of daily life improved from 54 to 91. Similarly, the other three components of KOOS score rose: symptoms from 64 to 91; sport from 42 to 89 and quality of life from 55 to 90.

From the patient’s point of view we need to accelerate the rehabilitation programme as soon as possible but meniscus implant needs limitations of both ROM and weight bearing status. Regarding the necessity to protect the meniscus implant this rehabilitation programme is slower than the one following ACL reconstruction. Finally, our observations were that the time when the patients return to full physical activity after ACL reconstruction with concomitant meniscus implantation does not differ from that found after isolated ACL reconstruction. In our opinion, good clinical results allowing our patients...
Cartilage Rehabilitation: Clinical Experiences

to return to normal activities of daily living and sports without pain validate the proposed surgery followed by personalized rehabilitation. The problem regarding instability of the knee joint along with cartilage damage is common knowledge due to the fact that it consequently leads to damage of articular cartilage. When taking into consideration promising outcomes of studies on 10 patients, we have been working on making the rehabilitation programme faster and more perfect in order to restore the functions of knee joint and avoid pain or its instability at the same time.


Dennis C. Crawford, MD, PhD and Micah B Naimark, BS, USA

Meniscus injury is a known risk factor for the development of knee osteoarthritis. Assessing knee function in patients with meniscus injury is important not only to guide treatment decisions and rehabilitation for this common pathology, but also to collect longitudinal data about physical dysfunction associated with meniscal injury and the potential future development of knee osteoarthritis.

Outcomes for patients treated for meniscus cartilage injury are frequently assessed with standardized questionnaires. As patients with meniscus tears may alter their activities or movements to avoid pain and compensate for their injury, questionnaires based on patient perception may not accurately reflect joint function. Furthermore, questionnaire responses can be influenced by other psychosocial factors unrelated to the injured joint, including depression, fatigue, and cognition. While questionnaires identify symptoms that are relevant to the patient, performance-based measures may provide additional information about the actual mechanical function of the joint.

We developed a battery of performance-based assessments designed to reproduce knee movements required for everyday living. The battery consisted of nine test-items: active range of motion, passive range of motion, sit-to-stand, stair ascent, stair descent, step-ups, step-downs, star lunges, and 6-minute timed treadmill travel (Figure). In addition to capturing objective measurements of performance, patients were asked to rate their pain and difficulty on a visual analog scale after completing each task.

Fifty patients diagnosed with isolated torn menisci and scheduled for arthroscopic meniscus surgery underwent the test on three occasions: twice pre-operatively to assess reproducibility and once post-operatively to determine response to treatment. Questionnaire data including the Knee Injury and Osteoarthritis Outcome Score (KOOS) and International Knee Documentation Committee (IKDC) Subjective Form were also obtained. Results of our initial study to validate this battery were recently presented at the Osteoarthritis Research Society International’s (OARSI) 2011 World Congress on Osteoarthritis and have been submitted for publication.

All performance-based assessments demonstrated strong interrater and intrarater reproducibility. The greatest reproducibility was observed with star lunges and treadmill travel, the two tasks with the highest motion complexity. On questionnaires, patients had a 53% improvement in IKDC subjective scores and substantial increases in all 5 KOOS subscales, with the highest improvement of 65% in the KOOS quality of life scale. Patients reported similar improvements in pain and difficulty with the performance-based battery of tests. Objective measures also revealed an improvement, but to a lesser degree. The greatest change in performance was seen with activities that placed high loads on the knee joint such as stepping and stair tasks. Patient performance on these tasks improved on average 10–15% after surgery.

This initial study suggests performance-based assessments can reproducibly assess knee function in patients with meniscal cartilage injury. Interestingly, patients tended to report large reductions in symptoms out of proportion to their improvement in physical performance. While performance-based assessments might require more effort to administer, they may offer data about underlying joint function that is distinct from patient-reported symptoms and questionnaires. We suggest performance-based assessments could be a useful clinical and research tool for monitoring cartilage injury, treatment, and rehabilitation. Similarly, these assessments may be useful for return to work guidelines or performance level criteria. Further investigations outlining necessary levels of function for commonly performed tasks could be of interest.

References:

Physiotherapy after cartilage repair: Experience from Clínica CEMTRO (Spain) Fernando García-Sanz, José Luis Lara Cabrero, Pedro Guillén-García, Elena Rodríguez-Iñigo, Juan Manuel López-Alcorocho, 1Physiotherapy Service, Clínica CEMTRO, Madrid, Spain, 2Research Unit, Clínica CEMTRO, Madrid, Spain, e-mail: aure.castillejo@clinicacemtro.com

After autologous chondrocyte implantation, physiotherapy is essential for a good recovery of the joint and to reach functional capacity of the patient as soon as possible. However, postoperative rehabilitation should take into account the “biological time” to guarantee the fully viability of the implant. Therefore, our protocol of rehabilitation considers this issue. In this communication we are going to describe the protocol followed in Clínica CEMTRO after autologous chondrocyte implantation in the knee or in the ankle. Our protocol has been used in 334 cases in the knee and 35 cases in the ankle. First, we have to emphasize the advantages of the arthroscopic technique without immobilization versus the open surgery. In our protocol, we have established an initial unloading phase for 8 weeks to allow for the biological integration of the implant into the joint. The goal of this first phase is to recover the mobility of the joint. To achieve this goal, we routinely use continuous passive movement (CPM) (Figure 1) and manual interactive mobilization of the joint performed by the physiotherapist. With an individualized manipulation we can functionally dose the intensity of the rehabilitation based on clinical parameters such as joint effusion and hypertonic muscle response, which help to monitor how much load and activity the joint can bear. We believe that the early mobilization of the joint can avoid the complications associated with immobilization and aids the early recovery joint function while supporting chondrocyte physiology through movement of the synovial fluid.

In the second phase, we the joint is submitted to progressive mechanic load. The use of scales (Figure 2) allows us to quantify the progress in joint loading, always under the surveillance of both the physician and the physiotherapist working as a team to supervise any slight sign of overload of the joint. During this second phase, muscle-potentiation is initiated to recover the functional parameters of muscle strength as soon as possible. In order to respect the viability of the implantation, initial muscular work is performed in open kinetic chain exercises in a biomechanical position or range of motion which guarantees the minimum load of the repaired cartilage defect.

The rehabilitation protocol ends with a third phase of patient re-adaptation to normal activity, but modulating this activity to the joint response. It is important to assess joint effusion to appropriately dose activity progression.

In conclusion, the rehabilitation process aims to recover the functional parameters and the patient’s quality of life as soon as possible, without placing the implant in danger. To achieve this goal, it is necessary to respect the biology of the implant, to start early mobilization of the joint and to assure at all times the acceptance of the load by the joint using close surveillance of the team of treating physician and physiotherapist. We do not use local electro-thermotherapy because its effect on the cellular development in the implanted area is not known. However, we use moderate cryotherapy and manual therapy as the mainstay of our physiotherapy treatment.
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The OFR takes place on a soccer field (grass or synthetic, outdoors or indoors) under the supervision of an experienced athletic trainer (Figure 1). Each session lasts about 90 minutes, from 3 to 5 times a week (depending on the athlete’s activity level), for at least 10 weeks. It consists of progressive sport-specific exercises (Figure 2) and it gradually allows the athlete to return to sport.

A recent study showed that athletes treated with OFR and Isokinetic training after arthroscopic second-generation autologous chondrocyte implantation (Hyalograft C) had a faster return to normal training (8.6±1.7 months) and an earlier return to competition (10.6±2.0 months) compared to the control group (10.6±1.7 and 12.4±1.6 respectively). These results and the significant improvement in the International Knee Documentation Committee (IKDC) subjective score (44.4±2.9 pre-operative; 84.7±11.7 at 1 year of follow-up; 90.7±11.7 at 5 year of follow-up) support our hypothesis that an intensive rehabilitation may allow an earlier return to sport without jeopardizing clinical and functional outcome over time.

The return to sport in term of time and clinical outcome is influenced by several factors such as the patient’s characteristics (age, activity level, motivation, rehabilitation goals) and the type of surgery. In a study by Mithoefer et al1 a bout return to competition after autologous chondrocyte transplantation, 83% of high level soccer players returned compared to only 16% of amateurs. As a matter of fact most of high level athletes are young, have shorter duration of symptoms and high motivation. They also generally follow a supervised rehabilitation.

Kon et al6 recently compared the functional recovery in a population of soccer players after two different surgical techniques. The same step-based rehabilitation protocol was used. The microfracture (MF) group returned to team in 6.5 months and the arthroscopic second-generation autologous chondrocyte implantation (Hyalograft C) group in 10.2 months. The return to competition was after 8 and 12.5 months, respectively. IKDC subjective score showed similar outcome at 2 years follow-up in both groups (MF 86.8±9.7 vs. Hyalograft C 90.5±12.8), but significant better results in the Hyalograft C group after 5 years (MF 79.0±11.6 vs. Hyalograft C 91.0±13.9). So, microfracture allows a faster recovery with worst outcome over time, while Hyalograft C has a delayed return to competition with more durable clinical results.

References:

Rehabilitation protocol after cartilage repair with BMAC and a collagen-based matrix Georgios Karnatzikos, MD, Anup Kumar, MD, M. S. Somanna, MD, Alberto Gobbi, MD, O.A.S.I. Bioresearch Foundation, Gobbi N.P.O., Via Amadeo 24 Milan Italy, Georgios Karnatzikos (giokarnes@gmail.com)

Cartilage has a limited healing potential due to the presence of few specialized cells with low mitotic activity and the lack of vessels and of undifferentiated cells that can promote tissue repair. Many surgical techniques have been utilized to improve cartilage lesions healing such as microfracture and autologous chondrocyte implantation (ACI). Gobbi et al1 recently published their results on a single-step surgery utilizing autologous bone marrow aspirate concentrate (BMAC) containing mesenchymal stems cells (MSCs) and growth factors for cartilage repair in large osteochondral lesions, measuring even up to 22 cm² in size.

The goals of cartilage repair are to restore an articular surface that matches the biomechanical and biochemical properties of normal hyaline cartilage and to prevent the progression to
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osteochondritis. Additionally, associated pathologies as ligament instability, meniscal absence and axis deviation should be treated before or in a concomitant procedure in order to achieve safe return to previous activities and prevent joint from high mechanical stresses and progressive degeneration. Rehabilitation: The rehabilitation protocol after cartilage repair with BMAC and collagen matrix patients should continue for 6–8 months and is similar to rehabilitation after second-generation ACI, based on current knowledge of the graft healing biology. Patient’s program is ideally designed to take into account different factors such as site and type of lesion, surgical technique, associated pathologies or surgeries, patient’s age, characteristics and expectations, psychological factors, social support and team work. Therefore the rehabilitation program is individualized respecting joint reactions and specific criteria of progression between rehabilitative phases. The rehabilitation program is divided in 4 functional phases characterized by specific objectives and criteria of progression (proliferative, transitional, maturation, and functional recovery). Della Villa et al. went further to suggest that an intensive rehabilitation protocol following cartilage repair procedures which included isokinetic and on-field activities positively affected graft maturation and shortened return to play time.

Rehabilitation Progression: The rehabilitation protocol is based on recovery of full range of motion, strength, and sport specific skills without pain and swelling and allows a safe progression. Joint reactions and clinical signs should be considered together with functional criteria for load progression, under surgeon’s supervision. Certain goals within each phase are expected to be achieved at a particular time-frame (Table 1). Any delays encountered demand close attention while progression from one phase to the next is allowed if cleared by the managing physician. Important issues related to weight-bearing, range of motion, strength and functional re-training are addressed at specified intervals and are the parameters used to judge the progression.

Weight-bearing: While maturation of newly formed tissue would take time to be completed, protection against excessive stress and loads are emphasized especially during the immediate post-operative period and the early phases of rehabilitation. In addition, patients should be advised regarding certain positions that should be avoided as determined by the defect size and location. Patients with anterior femoral condyle lesions would have to avoid loading the knee in extension; posterior condylar lesions should avoid loading at flexion angles greater than 45°; while trochlear lesions should not be loaded at angles greater than 30° of flexion. At this time, focus is shifted to strength training and neuromuscular exercises. Regaining muscular control and strength protect the graft site by effectively absorbing the forces that act through the joint surfaces and the treated lesion.

Bracing: The program should consider provisions that would allow patients to be mobile without compromising the delicate status of the graft. This is achieved with the use of a brace locked at 0° which together with the use of crutches would permit non-weight bearing ambulation while protecting the graft. Most protocols recommend non-weight bearing for two weeks following the surgery. After two weeks, partial weight-bearing can be initiated for both condylar and patellofemoral lesions. However, for patients with trochlear lesions weight-bearing progression should primarily be conducted with the leg locked in full extension. As the strength of the quadriceps muscles are regained, the patient can shift to one crutch at around the fourth week. At the same time, the brace can be gradually released from a locked position at increments of 20°–25°. Progression in unlocking the brace has been demonstrated to be slower for those with trochlear lesions.

Continuous Passive Motion (CPM): During the immediate post-operative period, the transplanted joint is immobilized with a brace. The use of a CPM (continuous passive motion) machine is commenced after 24 hours. The advantage of using one has been reported by Salter et al study which demonstrated an enhanced modeling of the repair by influencing the integration and orientation of cells. The usual range by which the machine is set is from 0° to 40° initially which is increased by increments of 5° depending on the location of lesion. At four weeks post-operatively, patients should be expected to reach 90° to 110°.

Strength Training: Once the joint is pain-free and swelling has settled with full range of movement achieved, the rehabilitative can now be focused on strength training. Early quadriceps

<table>
<thead>
<tr>
<th>Phase</th>
<th>Objectives</th>
<th>Criteria to Progress</th>
</tr>
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<tbody>
<tr>
<td>1. Protection of the implant (0–6 weeks)</td>
<td>• Protect the transplant from excessive loads and shearing forces • Decrease pain and effusion • Gain full extension and gradual recovery of knee flexion • Retard muscle atrophy</td>
<td>• Full active knee extension • Knee flexion &gt; 120° to or minimum pain and swelling • No pain during weight-bearing • Adequate muscle recruitment (quadriceps)</td>
</tr>
<tr>
<td>2. Transition and recovery of gait (6–12 weeks)</td>
<td>• Return to normal gait pattern • Progressive recovery in daily functional activities • Increase the strength of the quadriceps and flexors • Recovery of full range of motion</td>
<td>• Normal gait • Recovery of nearly full ROM (full extension, flexion &gt; 135°) • Adequate muscle tone and neuromuscular control • No pain or swelling</td>
</tr>
<tr>
<td>3. Maturation and recovery of running (12–24 weeks)</td>
<td>• Return to a correct running pathway • Further increase in strength of quadriceps and flexors muscles • Further increase in functional activities level</td>
<td>• Running without pain/ swelling at 8 km/h for 10’ • Adequate recovery of coordination and neuromuscular control • Recovery of strength &gt; 80% contralateral limb • Single leg hop test: &gt; 80% contralateral limb</td>
</tr>
<tr>
<td>4. Turnover and sport specific recovery (24–52 weeks)</td>
<td>• Sustain high loads and impact activities • Recovery sport specific skills • Prepare athlete for a return to team and competition with good recovery of the aerobic endurance • Maintain a good quality of life, avoiding excess of body fat and preventing risk of re-injury</td>
<td>• Running without pain/ effusion at 10 km/h for 15’ • Recovery of strength &gt; 90% contralateral limb. • Single leg hop test: &gt; 90% contralateral limb • Recovery of sport specific skills</td>
</tr>
</tbody>
</table>

Table 1: Rehabilitation phases, objectives and criteria to progress between phases.
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control is emphasized and should be achieved within the first week following the implantation. During this time, isometric quadriceps exercises with the knee locked in extension are commenced. Isometric closed kinetic chain exercises then follow which place sufficient demand on the muscles for progressive strength training without overloading the grafted areas. Specific sports patterns: As the patient nears the completion of his rehabilitation, re-evaluation of specific activities that determine the type of physical demands that would constitute the patient’s lifestyle is performed. The various components of these activities are broken down and incorporated in the patient’s training. The end goal of which is to regain balance and the protective reflexes to prepare the patient for his gradual return to activities.

Conclusion: The rehabilitation protocol after cartilage repair with BMAC and collagen matrix represents an essential component of the treatment and is designed to facilitate the newly-formed tissue incorporation and to influence the successful outcome of the procedure.

References:

Introduction: MACI is a second generation autologous chondrocyte implantation technique used for the treatment of osteochondral defects. Specifically, harvested chondrocytes placed onto a 3-dimensional collagen matrix and implanted on the articular defect with fibrin glue®. This procedure has been performed at our institution with an arthroscopy since 2003 and in 2008 this standard rehabilitation protocol was instituted. The aim of this protocol is to provide a standardized outline of post-operative care for patients and their physiotherapists, as many patients are tertiary referrals and do not live near the clinic or the main physiotherapy office.

Rehabilitation Protocol: The short term goals (0–12 weeks) of this protocol work on slowly progressing weight bearing while preventing the deleterious effects of immobilization and rest, including arthrofibrosis, joint adhesions, muscle atrophy and pain. During the first 6 weeks the rehabilitation is focused on decreasing swelling, improving range of motion, preventing adhesions, and conservatively increasing the weight-bearing status. The rehabilitation must begin to create the environment that encourages the cells to proliferate while preventing a certain amount of deconditioning.

At two weeks the dressing, splint, and sutures are removed (Fig. 2). The patient’s ankle is placed into a CAM walker boot (Fig. 1) that is to be worn at all times except during physiotherapy, home exercises, and showering. The patient must maintain strict non weight-bearing (NWBB) with crutches at this time. During the two-four week post-op period, plan tar flexion-dorsiflexion, inversion and eversion ankle ROM exercises are started under the guidance of a therapist. The therapist also begins manual joint manipulations and gentle scar massage.

Figure 1: Example of the rehabilitation CAM walker boot used by patient after the two week point in the post-operative rehabilitation.
At the four-six week post-operative period the patient begins hydrotherapy and isometric strengthening of the ankle. From our experience, hydrotherapy provides a great benefit in the rehabilitation process and we prefer to get the patient in chest high water for all exercises. These exercises include walking forwards, backwards, and sideways, heel raises, cycling in water, and single leg balance. Touch weight-bearing (TDWB) is started on week five.

At six-twelve weeks post-operative the aim is to increase weight-bearing, begin gait re-education, and restore ROM ankle to normal levels. At week six the transition to full weight-bearing (FWB) begins and TheraBand strengthening exercises are initiated. Sliding foot stretching exercises, gait re-education, and low-speed no resistance exercise bike are started as well. Joint mobilizations and soft tissue massage should also continue during this time to continue to reduce the amount of swelling. During week 12 to six months post operatively the goals of the rehabilitation protocol at this point are to gradually return to more functional activity, while avoiding high impact exercise such as running and jumping. Progressive proprioception and strengthening continue and exercises are mainly closed chain. During the 12–18 week period the patient is taken out of the boot but is not allowed to have more impact on the joint besides walking. Single leg balance on the floor and transition to a pillow are introduced to improve stability and proprioception. More focused stretching and strengthening of the gastroc-soleus, including eccentric and concentric calf-raises, are initiated.

Figure 2: Healing anteromedial arthroscopy incision used for placement of the MACI graft.

The 18–24 week period continues the previous activities and still limits impact exercises. A wobble board is begun and an increase in the time of walking exercises continues. At six months the graft will be stable enough to continue to increase balance training and start a gradual increase of impact activities with an aim for full impact activity at twelve months.

Experience: The MACI procedure previously described has been performed on over 80 patients at our institution since 2004. The current protocol was instituted in 2008 and has been used with 26 patients. There were 13 female and 13 male patients in this group. The average age was 38 years old. We have found that rehabilitation is important as this group of patients usually has had 2–3 previous surgeries to their ankle prior to the MACI procedure and that the rehabilitation must also deal with the difficulties associated with a chronic injury. Our experience has shown us that patients will begin to have an increase in pain once they start their weight-bearing transition. The protocol may need to be adjusted and individualized to fit some of these patients’ needs, although typically they continue to improve in a timely fashion. Overall, we have found our patients to perform well with this rehabilitation protocol and compliance is excellent.

Early Rehabilitation Following Microfracture in the Hip
Marc J. Philippon, MD, Diana Patterson, Teddy Fagrelius, The Steadman/Philippon Research Institute, Vail, CO, USA

Microfracture is a marrow-stimulating procedure that allows undifferentiated stem cells to heal chondral injuries. The procedure, developed by Steadman, accesses pluripotent marrow cells via small subchondral perforations created in the site of the defect. A marrow clot forms in which stem cells will differentiate into stable, hybrid fibrocartilaginous tissue that covers the lesion. While there are other surgical procedures to treat articular cartilage defects, the microfracture procedure continues to grow in popularity due to ease of use and cost.

Microfracture of the hip is indicated with focal and contained full-thickness defects, partial thickness lesions in which the cartilage scrapes off down to the bone when probed, and cases in which unstable cartilage flaps overlay intact subchondral bone. It is crucial to have an adequate height of cartilage around the rim of the lesion as the rim functions to hold the clot in place. Contraindications for microfracture of the hip include partial thickness defects and chondral lesions related to a bony defect. Patients who are unwilling or unable to comply with postoperative rehabilitation protocols are contraindicated for this procedure.

The postoperative management parallels that established for microfracture surgery on the knee. Care is taken to prevent disruption of the marrow clot (Figure 1) and thus protect the environment for marrow and mesenchymal cells to differentiate and grow. Repaired defects in femoral condyles of horses showed at 8 weeks hyalinelike tissue in microfractured defects, increase in type II cartilage mRNA expression in repair tissue, and treated lesions contained more repair tissue filling the defect. Initially, cold therapy is used to provide pain relief and to diminish the inflammatory response. Initial physical therapy efforts can begin on the day of surgery, and should focus on regaining range of motion and prevention of adhesion development, while protecting the surgical repair and healing cartilage. Continuous passive movement, circumduction, stationary biking, and aqua therapy are all utilized. Regaining muscle strength and neuromuscular balance of the hip and pelvis is critical to long-term success of the surgical repair.

Candidates for microfracture surgery of the hip must be educated preoperatively that the rehabilitation protocol is a slow,
involved process, as it must never be shorter than the necessary time for natural osseous healing and cartilage regrowth. Its success depends highly on the patient’s expectations and commitment. Outcomes are not measured by the speed with which the patient returns to their prior activity, but their overall satisfaction and longevity of function.7

In the weeks following arthroscopic microfracture surgery, flat-foot weight-bearing of 20lbs (9 kg) is maintained for the first 8 weeks. Reduced weight-load allows for osseus healing, and the flat-foot position is preferred over the toe-touch position to prevent a flexion contracture. A continuous passive movement machine is used for 6 to 8 hours per day during their weeks of weight-bearing restriction to prevent adhesions and, possibly, promote fibro-cartilaginous growth.8 The CPM machine should place the hip in 10 degrees of abduction, move between 0 and 45 degrees of flexion, and be increased as tolerated.8 Following each episode of CPM activity, the patient should lie prone for 30–60 minutes to prevent hip flexor contracture formation. Circumduction exercises are performed at 0 and 70 degrees of flexion in both the clockwise and counter clockwise directions. The leg is moved in a circular motion with the patella always facing upward and in line with the shoulder. Use of circumduction (Figure 2) immediately postoperatively has reduced the formation of adhesions from 4% to 1.4% cases.9

Use of the stationary bike, set with no resistance on the operative leg and the seat set high enough to prevent excessive flexion, starts on the day of surgery. Resistance can be added as tolerated.6 Aqua therapy is used to regain ROM and strength in a low-impact non-weight-bearing environment. Sessions are limited to 10–15 minutes and monitored to keep the patient’s ROM small. Patients walk in the pool to facilitate developing the proper walking gait and pelvic muscle strength while protecting the microfractured area from impact. When the patient is off crutches they can run in the pool starting with chest deep water and progressing to shallower water. Underwater treadmill running is not recommended as it introduces a secondary shearing force to the surgically repaired area.10

Regaining strength in the hip and core muscle groups and planes of motion is critical to the success of the rehabilitation and overall surgical procedure. Resolving maladaptive muscle patterns at this point in the athlete’s life can help to prevent future problems with the surgically repaired hip and prolong careers. Exercises used to accomplish this goal start with sub maximal isometrics in the first days after surgery, and progress as tolerated. Significant work towards stabilizing the pelvic musculature and emphasizing correct firing patterns can be accomplished in the 8 weeks before weight-bearing, which enables the patient to progress more rapidly once normal gait exercises are begun.5,10

References:
Part 4 – Member’s Experiences

Care should especially be taken concerning knee joint angle and the contact area in rehabilitation planned following autologous osteochondral grafting for knee cartilage lesions: A report of two cases. Hiroshi Kuroki1, Toru Oka2, Taizo Furukawa1, Masahiko Kobayashi1, Yasuaki Nakagawa1

1Department of Physical Therapy, Human Health Sciences, Graduate School of Medicine, Kyoto University, 2Department of Physical Therapy, Kyoto police Hospital, 3Department of Orthopaedic Surgery, Graduate School of Medicine, Kyoto University, 4Department of Orthopaedic Surgery, National Hospital Organization Kyoto Medical Center (Japan), kuro@hs.med.kyoto-u.ac.jp

Autologous osteochondral grafting surgery is one of the recently evolved methods to create hyaline repair tissue in articular cartilage lesions. Recent studies showed that this surgery appears to be a promising alternative for the treatment of small and medium-sized focal cartilage lesions in both of weight-bearing and non-weight-bearing joint surfaces(1–4). The knee joint, which consists of the weight-bearing lateral and medial tibio-femoral surfaces and the non-weight-bearing patello-femoral surface, is one of the most frequently treated joint by this surgery. Because size and location of cartilage lesions differ in each patient, successful management after the autologous osteochondral grafting to the knee has always been a challenge for rehabilitation specialists and orthopaedic surgeons.

The authors present two clinical cases of patients who had undergone autologous osteochondral grafting. Authors recommend that the return of weight-bearing is gradual, usually non-weight-bearing for the first 2 or 3 postoperative weeks, partial weight-bearing for 3 to 5 weeks postoperatively and return to full weight-bearing 5 to 8 weeks postoperatively. Strengthening using the open kinetic chain concept (OKC) and the closed kinetic chain concept (CKC) is applied in the first 3 weeks postoperatively and after 3 weeks, respectively. Because the program for each case respects both the period of non-weight-bearing and the knee angle without putting the osteochondral grafts at risk depending on size and location of the cartilage lesions, different postoperative rehabilitation programs should be planned for each case, especially in the strengthening program (Table).

Case 1 is a 15-year-old male with 2 osteochondral plugs (diameter 8 mm, length 15 mm) grafted to the cartilage lesion (size, 130 mm2) on the posterior part of the medial femoral condyle (Fig. 1). Isometric strengthening at 0 degrees and isotonic strengthening at 0–30 degrees of knee flexion were applied in the first 3 weeks postoperatively so as not to increase contact pressure on the graft, paying careful attention to the contact area (Fig. 2, upper)(5). After 3 weeks postoperatively, CKC strengthening was added using a pneumatic chair exercise at 30 degrees of knee flexion and the squatting exercise at the 30–45 degrees of knee flexion. After 5 weeks postoperatively, the OKC exercise was unrestricted and the CKC of the squatting exercise was performed at between 0–45 degrees. The CKC exercise was unrestricted after 8 weeks postoperatively.

Case 2 is a 27-year-old male, with 2 osteochondral plugs (diameter 8 mm length 15 mm) grafted to cartilage lesion (size, 135 mm2) on the central part of the patellar groove (Fig. 1). Isometric strengthening at 0 or 90 degrees of the knee and isotonic strengthening at 90 and 120 degrees was applied in the first 3 weeks postoperatively so as not to increase contact pressure on the graft, paying attention to the contact area (Fig. 2, lower)(6). After 3 weeks postoperatively, strengthening using the pneumatic chair exercise at 45 degrees and the squatting exercise between 0–45 degrees was performed. After 5 weeks postoperatively, the OKC exercise was unrestricted and the CKC of the squatting exercise was performed at the between 0–60 degrees. The CKC exercise was unrestricted after 8 weeks postoperatively.

Each case successfully recovers their muscle strength, range of motion and pain score using the numeric score and returns to activities of daily living and sports at postoperative 8

Fig. 1 Cartilage lesion was posterior of medial condyle in case 1 (A) and patellar groove in case 2 (C). Two plugs were grafted in each case (B, D).

Fig. 2 Knee joint angle and contact area in the tibio-femoral surface (upper)(5) and in the patellar surface (lower)(6).
Medial patellofemoral ligament reconstruction and Autologous Matrix-Induced Chondrogenesis (AMIC): a case report

Gille J*, Riepenhof H**, Oheim R**, Schagemann J*, Kienast B**, *University of Schleswig-Holstein, Campus Luebeck, Department of Trauma and Reconstructive Surgery, Luebeck, **BG-Trauma Hospital Hamburg, Trauma and Orthopaedic Surgery, Hamburg

Introduction: The treatment of traumatic chondral defects of the patella in young, active patients remains a challenge. The goal of treatment is to provide a well functioning, properly aligned knee that can endure a wide range of activity. Cardi
gle defects at the patella commonly occur in recurrent lateral patellar dislocation, subluxation and functional instability. The importance of the medial patellofemoral ligament (MPFL) as the primary soft-tissue restraint to lateral displacement of the patella has recently been corroborated by several studies, and the MPFL is always injured to some extent during traumatic lateral patellar dislocation. We present a case for combining Autologous Matrix Induced Chondrogenesis (AMIC) for cartilage repair and medial patellofemoral ligament reconstruction for patellar tracking. This report focuses on the rehabilitation program that needs to be adjusted when two operative procedures are combined.

Case report: A 22 y.o. female with a localized chondral defect at the patella presented in our clinic. She had a 4 year history of recurrent patellar dislocation. She reported that her knee functionally limited her and she felt that her patella would “pop out of place” during every day activity. A MRI scan was undertaken, reporting a shallow trochlea groove, a lateral patellar tracking and a cartilage lesion down to the subchondral bone at the medial patella. A MPFL repair in combination with an AMIC was recommended. At the time of surgery a diagnostic arthroscopy was performed and a cartilage lesion grade III-IV according to the Outerbridge classification was seen (Fig. 1a). For the treatment of the cartilage lesion (2 cm²) an AMIC procedure was performed (Fig.2a,b) was performed followed by an MPFL repair as prior described. Behind the background of the MPFL repair, the patient was postoperatively placed in a knee immobilizer in 20° of flexion. Already on the day of surgery she was taught an exercise program including a limited range of passive knee flexion of up to 60° and how to begin chain activities. After 2 weeks, leg raising and quadriceps setting exercises were instituted and range of motion was increased as tolerated with no restrictions. Although the patient was progressing well, she still had a limited knee extension at minus 10° and only 110° flexion limited by pain. Accordingly, she was transferred to our hydrotherapy class to improve pain

<table>
<thead>
<tr>
<th>Therapeutic exercise</th>
<th>Patellar groove</th>
<th>Site of lesion</th>
<th>Condyle, anterior</th>
<th>Condyle, posterior</th>
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<tbody>
<tr>
<td>Non-weight-bearing (first 2 or 3 weeks postoperatively)</td>
<td>OKC (isometric)</td>
<td>at 0 or 90 degrees</td>
<td>at 90 degrees *</td>
<td>at 0 degree *</td>
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<tr>
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<td>at the degree between 90 and 120</td>
<td>at the degree between 90 and 120 *</td>
<td>at the degree between 0 and 30 *</td>
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<td>CKC (pneumatic chair)</td>
<td>at 45 degrees</td>
<td>at 45 degrees **</td>
<td>at 30 degrees **</td>
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<tr>
<td>CKC (squatting)</td>
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<td>at the degree between 45 and 60 **</td>
<td>at the degree between 30 and 45 **</td>
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<tr>
<td>Bicycle ergometer</td>
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<td>20 min or more</td>
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<tr>
<td>Full weight-bearing (postoperative week 5 to 8)</td>
<td>OKC (isometric/isotonic)</td>
<td>at the degree between 0 and 60</td>
<td>at the degree between 0 and 45</td>
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<tr>
<td>CKC (squatting)</td>
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<tr>
<td>Exercise to return to sports (postoperative week 12 – )</td>
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<td>jog, jump, dash, cross-step, etc.</td>
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<tr>
<td>Return to sports (postoperative week 20 – )</td>
<td></td>
<td>more than 80 ° to maximum isometric strength of knee extension in the sound side</td>
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*: In case of medial condyle, being conscious of vastus lateralis and keeping eversion position of the ankle and foot.
In case of lateral condyle, being conscious of vastus medialis and keeping inversion position of the ankle and foot.
**: In case of medial condyle, keeping eversion position of ankle and foot and inner rotation of hip joint slightly.
In case of lateral condyle, keeping inversion position of ankle and foot and outer rotation of hip joint slightly.

weeks and 6 months, respectively. The authors recommend that care should especially be taken concerning knee joint an
gle and the contact area when therapeutic exercise programs and gradual weight-bearing exercise programs are planned following the autologous osteochondral grafting for knee cartilage lesions.

References:

Member’s Experiences

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In case of lateral condyle, keeping inversion position of ankle and foot and outer rotation of hip joint slightly.
Member’s Experiences

and range of motion. The patient continued with her home exercise program on non-gym days and was discharged from the physiotherapy department 8 weeks postoperatively.

Results: Following this rehabilitation program after AMIC with concomitant patella realignment surgery, when reviewed 6 months postoperatively, the patient reported that her knee felt “stronger” with no recurrent patellar dislocation, and was completely satisfied with her surgery. She had increased confidence in the use of her knee, full range of motion and had returned to her normal home and work activities.

Discussion: This single-case study describes a patient following AMIC and concomitant MPFL repair and a tailor-made rehabilitation program. This patient reported a successful outcome with the resolution of patella instability and relieve of anterior knee pain. The lack of a control group does not allow to establish whether one or the other procedure alone can provide both pain relief and functional improvement, but ethical reasons suggest that both conditions should be treated. Our results are in line with a similar study combining a distal realignment and membrane-seeded autologous chondrocyte implantation (MACI) leading to good results with significant increases in all outcome scales.

As with all rehabilitation programs, the patient’s management should be tailor-made to meet patient’s, physiotherapist’s and surgeon’s objectives. Our rehabilitation protocol does not immobilize the knee, although movement is limited initially, and encourages the return to functional activities. By not immobilizing the knee, the likelihood of the detrimental effects of the immobilization such as joint stiffness, articular degeneration and muscle atrophy can be reduced. The initial limitation of movement is based on the fact that the MPFL has its maximal restraint against patella lateralization in 30% of knee flexion.

Fig 2a, b: Surgical access to the patella. Fig 2a shows the debridement of the patellar cartilage lesion. Intraoperative findings after AMIC (Fig. 2b).

The Autologous Matrix Induced Chondrogenesis (AMIC) has proven to be a successful treatment and provides two major advantages; on the one hand it is a one-step procedure and on the other hand it is cost-effective with no need of in vitro cell expansion. In a case series of 27 patients we prior described a significant improvement in 4 different scoring systems after a follow-up of up to 36 months after AMIC. MPFL reconstruction has become the first choice for treating recurrent patellar dislocation and good midterm clinical results with up to 97% patient satisfaction and up to 10 years of follow up have been reported.

Fig 1a, b: Arthroscopic view at the articular surface of the patella. Fig 1a demonstrates the chondromalacia graded as III - IV according to Outerbridge classification, while Fig. 1b shows a smooth articular surface after AMIC with the matrix in place at the end of surgery.

Case report: patello femoral chondral lesion in a young female soccer player Danny van Caspel – PT, Central Military Hospital, Utrecht, The Netherlands

A 24 year old female medical student visited the department of physiotherapy 3 weeks after having suffered an injury during a soccer game. Presumably the kneecap was subluxated at the time of her injury. Magnetic Resonance Imaging (MRI) showed a grade 4 chondral lesion of the lateral trochlea of her left knee. The patient was scheduled for an autologous chondrocyte implantation (ACI). After consulting the orthopaedic department of the University Medical Centre Utrecht, the patient was sent to the department of physiotherapy for a preoperative screening. The importance of preoperative screening should be emphasized. It is important that the patient has a clear understanding of the postoperative process and involved exercise progression. Some important items of that process are the long duration of the rehabilitation and the continued motivation and dedication of the patient to the rehabilitation program. The patient presented with several favourable parameters: short duration of symptoms between injury and operation, young

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age, normal weight, high preoperative activity level with daily sports participation and positive motivation.

During the first arthroscopy, a second chondral lesion was seen: a defect of the patella. Conclusion: kissing lesions of the patella and trochlea. Two months after the first visit to the orthopaedic department, an autologous chondrocyte implantation of the trochlea and the patella was performed. After the operation, a bandage (tape) was applied distal and proximal from the knee joint. By using this tape method the contact between the opposite defects is minimized (Fig. 1).

The rehabilitation program for patello-femoral defects was used and MRI examination was performed to follow the morphology of the cartilage. Post operative rehabilitation included bracing in extension for 6 weeks. Full weight bearing with the brace was permitted after 3–4 weeks depending on the reaction of the joint and the controlled activation of the quadriceps. Continuous passive motion was used for 6 weeks, 6–8 hours a day. After 6 weeks it was permitted to take off the brace and resume a normal gait. Hydrotherapy was used as an ideal method to normalize the gait.

Rehabilitation after ACI must be a fine tuned therapy! Especially knowledge of the biological processes in the joint, combined with the loading of the joint during the different phases of the rehabilitation is essential. Load on the repaired structures at the different angles of joint loading should be considered depending on the location of the lesion. Biomechanical aspects of the patellafemoral and tibiofemoral joint should be well understood for ACI rehabilitation.

At 19 months postoperatively, the patient is doing very well. Mid- and high load exercises are tolerated without any problem and the patient is starting agility training and sports-related exercises in the upcoming months. It is difficult to predict when the patient will be ready to return to soccer. The combination of systematic rehabilitation and continued positive motivation and mental attitude increase her chance to return her to active sports participation.

Case Report: Rehabilitation and Isokinetic Testing after Cartilage Repair with Microfracture

Carlos Alberto Atherinos Pierri, Robson Dias Scoz, Fabricio Biscaro, Taylor Ferreira Orthopedics and Traumatology, Sports Medicine CORE – Florianópolis – Brazil

Articular cartilage damage has been heavily discussed in literature as surgical techniques and rehabilitation strategies evolve. The etiology of chondral injuries varies between trauma, degeneration, meniscal tears and even a poor biomechanical alignment. Even partial meniscectomy can be potentially detrimental for the cartilage tissue due to augmented contact pressures between femur and tibia. The ICRS has established an official classification for this cartilage lesion that is used worldwide. The treatment for cartilage injuries depends on their local defect characteristics and patient’s activity level. The microfracture technique was described by Steadman in 2001 and has been used with good results following the rehabilitation guidelines proposed by Reinold et al (JOSPT 2006). In some cases, when chondral injury is extensive, exercise-induced pain during rehabilitation can present a challenge for patient and physical therapist. Below we present a case that describes treatment options for this kind of patient:

Case Presentation: A 36 year old businessman and recreational surfer involved in a car crash 10 years ago began complaining of knee instability and swelling over the last 5 years. The patient reported two previous knee surgeries for the same problem, performed in another Brazilian state, with no success. Clinical history, physical examination, X-ray and magnetic resonance imaging revealed an anterior cruciate ligament tear, grade IV chondropathy and partial medial and lateral meniscectomy. The patient underwent anterior cruciate ligament reconstruction with hamstrings graft, Steadman’s microfractures of chondral defects located in the trochlea (2cm²) and the lateral femoral condyle (7mm).

Platelet rich plasma clot (PRP) was applied to the chondral repair site. The patient began continuous passive motion (CPM) therapy on the first postoperative day until the second week when he started using the bicycle. Crutches were used without weight bearing for 6 weeks and the patient performed the majority of exercises commonly prescribed and recommended after cartilage repair. After 12 weeks of rehabilitation, the patient still complained of edema, weakness and marked pain - mostly while doing exercises. The regular rehabilitation protocol was interrupted. The patient received a hylan G-F 20 intra-articular injection and started an isokinetic strengthening (Cybex-HumacNorm) protocol for 8 weeks, as suggested by Petersen et al (2009). It consisted of 6-8 concentric sets of 10 repetitions at different angular velocities, tree times per week with one-day minimum rest between intervals. The first set, so called a “warming set” was performed at 180 degree per second with 20-30 repetitions and 60 second rest. The other 8 sets use slower velocities (120, 90, 60 and 30 degree per second, two sets for each velocity). The patient started with higher velocities and the progresses to slower velocities. After 6 weeks the patient should be doing 5-6 sets (two 120, two 90 and one or two sets at 60 degree per second). The wor-
Cartilage Rehabilitation: Clinical Experiences

The first steps of rehabilitation: Patients are hospitalised in our clinic. Once the knee range of motion and the quadriceps condition is considered adequate, patients can start to load the operated limb in full knee extension.

The program of complex physiotherapeutic treatment of patients after arthroscopic reconstruction of cartilage by the AMIC method

Prusinska A., Piontek T., Ciemniewska-Gorzela K., Naczk J., Grygorowicz M., Dudzinski W., Rehasport Clinic, Poznan, Poland, Medical University of Poznan, Poland

AMIC (Autologous Matrix-Induced Chondrogenesis) is an innovative biological method of cartilage reconstruction that stimulates the natural potential of the organism to rebuild focal cartilage and bone-cartilage surface damage of no more than 1–2 cm². The aim of this study is to demonstrate complex physiotherapeutic treatment of patients after arthroscopic cartilage reconstruction (joint surface) by AMIC method; based on case studies among patients of our clinic.

The first steps of rehabilitation: Patients are hospitalised for one day and equipped with an angle-adjustable orthosis stabilizing the knee at 15° angle for the first 24 hours after surgery. We recommend walking with crutches in a normal movement pattern, without loading of the limb for the first 4 weeks. Then, loading should be gradually introduced so that the operated limb can be fully loaded within approximately 6 weeks when the patient should be able to walk without elbow crutches. The patient should perform proprioceptive exercises from the first day after the surgery. Knee joint flexion is limited to no more than 90° for the first 4 weeks after surgery. Two weeks after arthroscopy all patients attend an appointment with their doctor, have their stitches removed and undergo physiotherapy treatments in our clinic. Once the knee range of motion and the quadriceps condition is considered adequate, patients can start to load the operated limb in full knee extension.

The first 12 weeks of rehabilitation: In our protocol the most important aspects of rehabilitation after arthroscopic cartilage reconstruction are proprioceptive exercises, the range of motion (ROM) and isometric exercises that stimulate the quadriceps.

The range of motion is performed using continuous passive motion machine (CPM) and on a stationary bike with no loading for the first 4–5 weeks. In the initial stage, exercises simulating the quadriceps are only isometric, in weeks 5–6 squats are introduced but only up to 90° of knee flexion. The first proprioceptive exercises are in supporting conditions, after 5–6 weeks with full loading on unstable ground. During weeks 7–8 of the rehabilitation process the load is increased on the stationary bike, squats with additional weight are performed and exercises on one leg are introduced, along with exercise with an athletic trainer.

Biomechanical tests: We obtained, from objective measuring tools, results regarding the patient’s recovery. The first (basic) biomechanical tests are performed in the 12th week after arthroscopy; they are composed of postural strategy and neuromuscular control evaluation of lower limbs and the spine, using DELOS system, the assessment of ground reaction forces and symmetry during loading on lower limbs movement performed on dynamometric MTD platforms, measurement of isokinetic muscles strength and functional tests of basic movements patterns according to Gary Cook’s concept. Further rehabilitation activities are influenced by the results of these tests. If they meet the assumed criteria we introduce dynamic exercises, jogging training and advanced training with a physical education trainer. If the results do not meet the assumed criteria a patient returns to static exercises and the tests cannot be taken for another 3 weeks. The tests are done in the 6th and 12th month after the arthroscopy and they are always composed of the same elements. Additionally, a Functional Movement Screen is performed after the 6th month.

Today in our clinic there have been 30 patients who have been operated with the AMIC method, 15 at the 3-month post-surgical evaluation, and 6 patients at 6 months post-surgical evaluation. Among the group is one patient who is professional athlete that has already returned to a training regime in his football club. Having observed patients in our clinic it seems that the rehabilitation protocol we have created for patients after reconstruction of cartilage defects in the knee with the AMIC method, is not only successful but also enables patients’ recovery, and what is more, to full fitness.

References:

Editorial

ICRS Newsletter

The ICRS Newsletter is published bi-annually. In case of enquiries, comments or if you would like to send us your contribution or adverts, please contact office@cartilage.org

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Please submit your contributions to office@cartilage.org until end of May 2012
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Please ask your MACI implant representative for a copy of the Accelerated Rehabilitation Guidelines OR contact us at www.maci.com to request a copy.

www.maci.com

References:


MACI implant is not approved for use in the USA by the FDA, it is commercially available in Australia and select European/Asian countries.