

## Case Report

# Enhanced Cartilage Repair Technique with K-Wire Drilling Plus Subchondral Injected Plasma Rich in Growth Factors - A New Modified Microfracture Technique

Matthias Steinwachs<sup>1\*</sup>, Marcus Mumme<sup>1,2</sup>, Nicola Cavalcanti<sup>1</sup>, Ann-Catherine Steinwachs<sup>1</sup>

<sup>1</sup>SportClinic Zurich, Klinik Hirslanden, Witellikerstrasse, Zürich, Switzerland

<sup>2</sup>Department of Surgery, University Hospital Basel, Hebelstrasse Basel, Switzerland

\*Corresponding author: Matthias Steinwachs, Sport Clinic Zürich, Klinik Hirslanden, Witellikerstrasse 40 CH-8032 Zürich, Switzerland

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### Abstract

The world's most widely used micro fracture cartilage repair technique shows despite the satisfying clinical results at short-term, significant disadvantages of clinical outcome in the mid- and long-term. The reasons for this are the limited access to the bone marrow (3 mm deep), the significant injury to the load-bearing subchondral bone plate with hypertrophy of the bone and a limited chondral differentiation of the existing bone marrow cells with the formation of mechanically insufficient fibrocartilage. The technique presented here allows arthroscopic orthograde perforation of the subchondral bone plate with a thin K-wire to prevent extensive bone injuries, facilitates deeper perforation to access the cell-rich bone marrow, to address subchondral bone marrow edema pathology through intra-osseous injection of plasma rich in growth factors (PRGF<sup>®</sup>-Endoret<sup>®</sup>) and assist repair cartilage formation by providing autologous platelet factors locally.

### Introduction

Cartilage injuries are said to frequently lead to incomplete defect-regeneration due to the limited healing properties of hyaline cartilage [1]. As a pre-arthrotic deformity, this failure of restoration often results in progressive degeneration of the affected joint and a continuous function impairment [2,3].

Arthroscopic one-step micro fracture is the most common technique for cartilage repairs worldwide [2,4,5]. This method induces the formation of a repair tissue yet carries insufficient biomechanical features as well as an inadequate long-term weight-bearing capacity [2,4,6]. Firstly, more extended injury of the subchondral bone caused by the use of V-shaped top of micro fracture instruments is considered to be causative. Secondly, the shallow depth of perforation (3 mm) achieved by these devices only allows very restricted access to the subchondral pool of stem cells with poorly developed cell differentiation characteristics [7]. This restriction becomes very apparent with the hypertrophic formation of bone within the defective region and may be circumstantial

evidence for spontaneous osteogenic stem cell differentiation, excluding the significant chondrogenic differentiation [8]. Persistent bone marrow edema as a manifestation of the mechanical insufficiency of the injured subchondral bone, in combination with the biomechanical restrictions of fibrocartilage, are the main reasons for the histologically and clinically evident problems of this method [1,2]. Initial experimental data of the utilization of K-Wire for bone marrow stimulation was able to claim superiority in comparison to the conventional micro fracture technique [7]. Clinical and experimental data show that the additional use of platelet-rich plasma enhances the biological tissue regeneration in bone and cartilage naturally [7,9-16]. PRGF<sup>®</sup>-Endoret<sup>®</sup> is an autologous, leukocyte-free plasma rich in growth factors product, which regenerates tissue by the stimulating properties of thrombocytic proteins and provides stabilization due to fibrin and has shown healing and pain-reducing effect after injury of joints and bone [13,15]. Stimulation includes angiogenesis, cell migration, proliferation, and auto- and paracrine secretion when further modulation of the degradative reaction of inflammation

occurs. Nowadays, the treatment of articular cartilage lesions scarcely addresses subchondral bone as the locus of the tissue restoration. The herewith introduced arthroscopic technique is an enhanced approach to bone marrow stimulation employing tapered K-Wires with a perforation depth of 1 - 1.5 cm and the subchondral injection of activated autologous plasma rich in growth factors (PRGF®-Endoret®) as a treatment option for symptomatic full-thickness cartilage lesions or persistent bone marrow lesions (< 2 cm<sup>2</sup>).

### Surgical Technique

The proposed arthroscopic one-step method applies to full-thickness cartilage lesions ICRS grade III and IV with an indication for micro fracture (lesions smaller than 2 cm<sup>2</sup>) and persistent bone marrow pathologies in knee joints, ankle, hip, and shoulder joints. As a part of the recommended preoperative X-Ray and MRI diagnostics, associated pathologies should be followed to ensure adequate treatment.

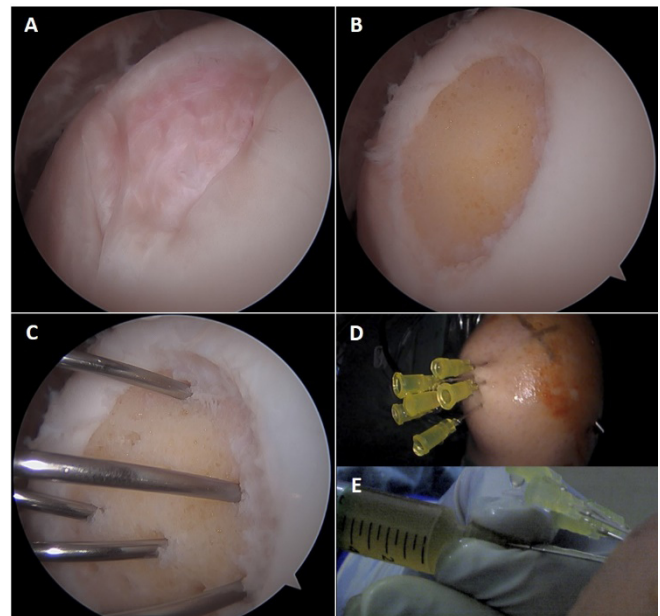
### Extraction of autologous PRGF®-Endoret®

The PRGF®-Endoret® collection kit is used to collect approximately 60 ml of whole venous blood, which transfers to the centrifugation tubes under sterile conditions. After the addition of citrate and 30 minutes of centrifugation with the PRGF®-Endoret® centrifuge, the supernatant (cell-free) fraction is piped off and inserted to a Plasma Transfer device. The PRGF®-Endoret® obtained can now be moved to the operating theatre for surgical therapy.

### Arthroscopic operation-antegrade defect application

Once the patient is resting in a supine position, their previously marked leg is provided with a tourniquet and inserted into a hydraulic leg lifter. The perioperative recommendation for antibiotic prophylaxis is a single shot of cephalosporin's. The surgeon must operate with a pressure-controlled arthroscopy, and the patient is required to receive partial or general anesthesia. After extensive skin disinfection and the application of sterile covers, access to the joint is gained by the usual arthroscopic standards with the appropriate arthroscopy portals. Firstly, all of the joint compartments require precise inspection; any additional therapies needed should be addressed before attending to the cartilage injury. For the treatment of full-thickness cartilage damage, the area at fault requires optimal visualization (Figure 1A). Subsequently, the surgeon must remove cartilage residue and prepare the boundary layer to the subchondral bone. The cartilage margins should be substantial and cut as vertical as possible utilizing a curette (Figure 1B). With a lengthy singular cannula and adjustment of the knee joint by flexion through the hydraulic leg lifter, orthograde access to the defect is sought. After a small puncture incision, a 1,25 mm-K-Wire is advanced percutaneously to the prepared defect site and drilled into the bone to a depth of approximately 1,5 cm using

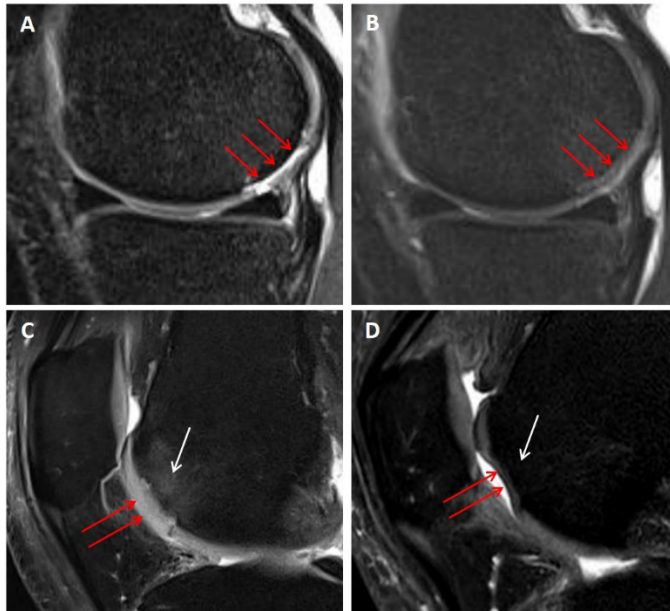
a drilling machine. This procedure requires repetition until there is an even number of apertures at a distance of approximately 3 mm to the base of the defect. Now several 70mm long and 20 Gauge cannulas are inserted percutaneously through the skin incisions into the drilled channels (Figure 1C,1D). After arresting the arthroscopic pumping system, PRGF®-Endoret® activated with calcium can be injected through needles via a 10 mL syringe with minute pressure into the subchondral bone (Figure 1E). After the removal of all needles, a CH10 Redon drainage is inserted intra-articular via the arthroscopic handle, operating through overflow without suction. The joint is placed in a safe stretched position so that the corresponding joint surface covers the treated defect. Single, interrupted sutures are used to seal the incision. Following wound closure, an elastic dressing wraps the leg, and an extension-orthosis leg brace is applied. Postoperatively bed rest is recommended until the following day. After, mobilization must be made with sole contact gait and knee joint angulation of 30 degrees' flexion to zero degrees' extension for two weeks, followed by four weeks of partial weight-bearing with increasing angles in flexion; amounting to Continuous Passive Motion (CPM) treatment for two hours each day for the entire first six weeks. After the seventh postoperative week, a gradual transition to full weight-bearing activity is recommended.



**Figure 1:** (A): Arthroscopic technique for cartilage repair with antegrade application. Arthroscopic visualization of the cartilage defect. (B): Debridement of the defect down to the subchondral bone and to rim of healthy cartilage. (C, D): After 1.25mm K-wire drilling, 20 gauge cannulas are inserted percutaneous into the drill holes. (E): And the PRGF®-Endoret® is injected intraosseous.

The enhancement of microfracture technique can either

support the reduction of marrow edema or the formation of cartilage repair tissue (Figure 2).



**Figure 2:** Demonstration of successful repair in a case of a female patient with symptomatic cartilage defect of the medial femoral condyle (A, red arrows). 6 months post-surgery, complete defect filling is achieved (B, red arrows). In the case of male patient with symptomatic cartilage delamination (C, red arrows) and corresponding bone marrow edema (C, white arrow) of the trochlea femoris, a partial defect filling (D, red arrows) and complete resolution of bone marrow edema (D, white arrow) is achieved 6 months post-surgery.

#### Arthroscopic operation - retrograde defect application

In the presence of chronic bone marrow and stress edema, stage I or II Osteochondritis dissecans or early stages of osteonecrosis without full-thickness cartilage damage, the technique described above can also be beneficial in the form of retrograde drilling with the injection of PRGF®-Endoret®. This reasoning is addressed with the same arthroscopic method as the one mentioned previously. Firstly, if the contrast-enhanced MRI displays edema in the joint region, then it requires a detailed examination. Any intra-articular mechanical causes (e.g., meniscus lesion) for the edema must be corrected in advance if necessary. Subsequently, at least two 1.25 mm-K-Wires must be drilled into the area of edema from the extra-articular side, if required this step can be assisted by X-Ray control. Long cannulae are then inserted into the bone via the small bone perforations and activated PRGF®-Endoret® is injected with minute pressure into the area of bone marrow edema. Before injection, at least two needles should be placed into the bone perforations to ensure the intramedullary

pressure relief of the bone marrow during the injection. Following the removal of the needles, the operation is terminated identically as for the anterograde application. The postoperative procedure is managed with four weeks of partial weight-bearing activity.

#### Discussion

Untreated cartilage damage can lead to the development of arthrosis which carries a substantial socioeconomic cost over numerous years [1]. According to international guidelines, symptomatic ICRS grade III and IV cartilage defects of less than 2 - 2.5 cm diameter are usually treated with an arthroscopic micro fracture. Clinical and histological studies that such treatment causes the formation of fibrous cartilage regenerates with reduced mechanical stability, the development of hypertrophic bone reactions and persistent bone marrow edema [17]. Culminated by the clinical outcome deteriorating after an initial improvement within three to five years [2,4,6,18]. The modifications, as mentioned above, intended to improve the methodological and technical problems of this technique.

On the one hand, the coarse perforation of the subchondral bone by the V-shaped micro fracture instruments causes significant damage and destabilization to the subchondral plate; on the other hand, the perforation depth of solely 3 mm allows only minimal access to the regenerating cell pool. The bone damage results in increased bone healing, which ends in predominantly osteogenic and fibrous tissue differentiation. This modulation of tissue is histologically manifest by bone hypertrophy, by the quality of the fibrous regenerate and radiologically by bone marrow edema [17,19], leading to persistent clinical apparent pain at the treated site during weight-bearing. The method presented in this paper employs thin K-Wires to reduce the damage to the weight-bearing subchondral bone layer and the resulting problems such as cancellous bone edema and hypertrophic bone reaction [20]. The perforation depth of 1 - 1.5 cm allows the recruitment of stem cells from the bone marrow to a significantly higher degree [7,21]. Through an additional application of PRGF®-Endoret® in the subchondral bone and the defect area, the biological process of tissue regeneration, both in the bone and cartilage, is supported by natural initiators of the wound-healing phases [13].

Further controlled studies will be necessary to confirm if patients can benefit from reduced tissue damage and biological tissue repair enhancement by this new technique in the mid- and long-term.

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