

Arthroscopic Treatment of Hip Chondral Defects With Bone Marrow Stimulation and BST-CarGel



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Abstract: Microfracture, the current standard of care for the treatment of non-degenerative chondral lesions in the hip joint, is limited by the poor quality of the filling fibrocartilaginous tissue. BST-CarGel (Piramal Life Sciences, Laval, Quebec, Canada) is a chitosan-based biopolymer that, when mixed with fresh, autologous whole blood and placed over the previously microfractured area, stabilizes the blood clot and enhances marrow-triggered wound-healing repair processes. BST-CarGel has been previously applied in the knee, with statistically significant greater lesion filling and superior repair tissue quality compared with microfracture treatment alone. In this report we describe the application of BST-CarGel for the arthroscopic treatment of hip chondral lesions. Our preliminary data suggest that our BST-CarGel procedure provides high-quality repair tissue and therefore may be considered a safe, cost-efficient therapeutic choice for the treatment of hip chondral defects.

Articular cartilage lesions, especially at the anterosuperior wall of the acetabulum, represent—after labral lesions—the most common pathology found in patients undergoing hip arthroscopy. These lesions frequently cause pain and functional limitation and are usually associated with other abnormalities such as avascular necrosis, dysplasia, osteochondritis dissecans, trauma, labral tears, and femoroacetabular impingement. Irrespective of the cause, chondral lesions are rarely able to spontaneously self repair, and it is likely that if left untreated, progression to more generalized degeneration will occur.^{1,2}

Several strategies have been developed with the aim to achieve repair tissue showing biochemical and biomechanical characteristics comparable with those of the surrounding native cartilage. The current standard of care for the treatment of small chondral defects in the

hip, as in other joints, is microfracture.³ However, this technique is recognized to be an incomplete solution to deal with these lesions. The poor quality of the filling fibrocartilaginous tissue, which often lacks hyaline articular structure, and the highly variable clinical outcome frequently observed have been mainly associated with the instability of the marrow-derived blood clots formed in the lesion, which shrink and detach as a consequence of platelet-driven clot retraction.⁴

The application of BST-CarGel (Piramal Life Sciences, Laval, Quebec, Canada) represents an approach in which the microfracture treatment has been optimized by the use of a soluble chitosan-based polymer scaffold that physically stabilizes the blood clot in the cartilage lesion. Chitosan is an abundant glucosamine polysaccharide derived from the exoskeleton of crustaceans exhibiting adhesivity to tissues, low toxicity, and biocompatibility and biodegradability characteristics. BST-CarGel is obtained by dissolving chitosan in glycerophosphate buffer, resulting in a liquid solution that does not interfere with normal coagulation. When mixed with fresh, autologous whole blood and placed over the defect, BST-CarGel reinforces the fragile blood clot by impeding its retraction. Moreover, chitosan's cationic nature improves clot adherence within the lesion, ensuring prolonged activation of tissue repair processes by maintaining critical blood components above marrow access holes.⁴⁻⁶

The purpose of this article is to describe the application of BST-CarGel in combination with a hip arthroscopic

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microfracture procedure for the treatment of isolated full-thickness acetabular cartilage defects.

Technique

The described technique is indicated in young adult patients presenting with chondral delamination as a result of a mechanical conflict (femoroacetabular impingement). The diagnosis can be made by magnetic resonance imaging, magnetic resonance arthrography, or delayed gadolinium-enhanced MR imaging of cartilage (dGEMRIC) (Fig 1). Hip arthroscopic surgery is performed with the patient placed in the supine position on a traction table (Hip Positioning System with Active Heel Technology; Smith & Nephew, Memphis, TN). The hip joint is distracted, and standard anterolateral and distal mid-anterior portals are used as the viewing portal and working portal, respectively. An image intensifier is used to evaluate distraction and to guide accurate portal placement. Pre-positioning of the anterolateral portal is performed with a 15-cm, 18-gauge arthroscopic needle (Smith & Nephew). A guidewire is then placed through the needle. The needle is removed, and a 12-cm, 5-mm-inner diameter arthroscopic cannula (Smith & Nephew) is passed over the wire. Once the portal has been established, a 70° arthroscope (Smith & Nephew) is inserted and a complete diagnostic evaluation of the hip joint without irrigation fluid is performed. The distal mid-anterior portal is created under arthroscopic control, and the integrity of the articular cartilage is further assessed with a probe. Irrigation fluid is then introduced into the joint using an arthroscopy pump (ConMed, Utica, NY) with the pressure set at 40 mm Hg.

Chondral debridement of delaminated cartilage is performed around the labral detachment with curettes and motorized shavers (ConMed) to completely remove damaged cartilage and to obtain well-defined, stable margins between the healthy cartilage and the cartilage defect (Fig 2A). The calcified layer is then carefully removed to expose the subchondral bone while preserving its integrity. The exposed area is microfractured

with 60° to 90° arthroscopic awls (Smith & Nephew) as per the standard procedure, penetrating the subchondral bone to a depth of approximately 3 mm, with holes placed every 2 to 3 mm until covering the entire surface (Fig 2B). Adequate penetration of the subchondral bone can be assessed by observing bone marrow bleeding and/or fat droplets from the microfractured holes after reduction of the irrigation pressure. Pincer and cam lesions are then treated if needed. Labral refixation is performed with bioabsorbable suture anchors (Osteoaptor, 2.3 mm; Smith & Nephew), with careful insertion of these at the edge of the acetabular rim to ensure containment of the chondral lesion. Holes for labral anchors are drilled every 5 mm, and in most cases 3 to 4 implants are needed. After that, traction is released to reach the peripheral compartment, and cam deformity is accessed by horizontal capsulotomy that, if required, can be extended to a T-capsulotomy, mainly through a distal-lateral portal. Osteoplasty of the femur is carried out with a motorized 4.5-mm burr (ConMed). Although osteoplasty can be accomplished at this point or at the end of the surgical procedure, we strongly recommend removing the bony prominence before applying BST-CarGel to keep traction for no more than 2 hours. After osteoplasty, the capsulotomy is partially closed (the longitudinal portion when a T-capsulotomy is performed) with side-to-side sutures using lateral suture passing (Acupass; Smith & Nephew), and traction is reapplied to access the central compartment again.

The BST-CarGel mixture is prepared according to the manufacturer's instructions; this can be performed by a nonsterile nurse while the lesion is being surgically prepared. In brief, BST-CarGel is prepared by dissolving chitosan solution in an aqueous glycerophosphate buffer. The resulting solution is then manually mixed with fresh, autologous whole peripheral blood at a ratio of 3:1 (blood to BST-CarGel). This mixture can be prepared 15 to 25 minutes before the implantation time to achieve the optimal physical and mechanical properties of the product for delivery to a vertically oriented

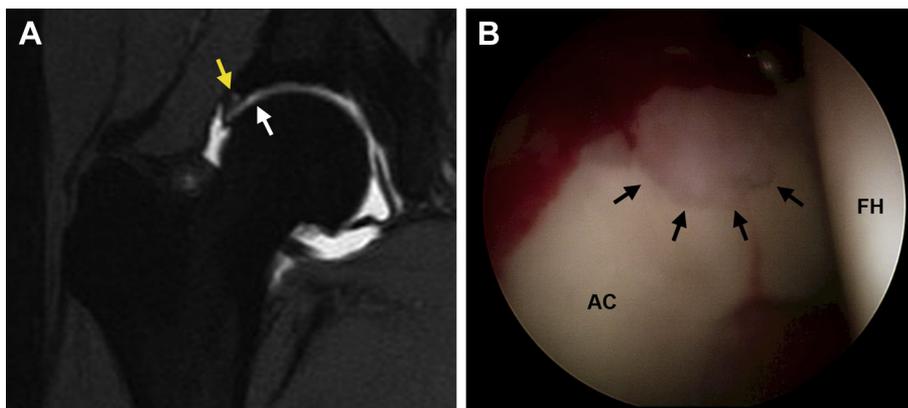
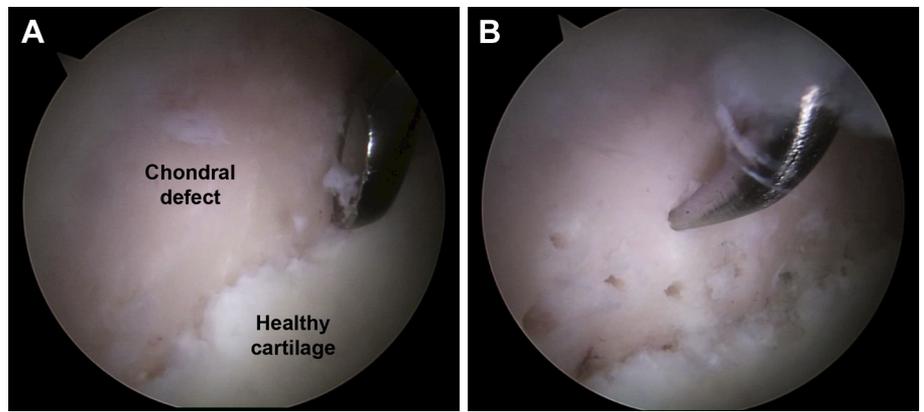


Fig 1. Identification of chondral lesion. (A) Coronal T1-weighted fat-saturated magnetic resonance image of the right hip showing a cartilage defect in the acetabulum (white arrow). One should note that there is a bone cyst in the subchondral bone (yellow arrow). (B) Arthroscopic view of the right hip from the anterolateral portal with the patient placed in the supine position. The arrows indicate a limited chondral lesion in zones II and III of the acetabulum, according to the mapping system proposed by Ilizaliturri et al.⁷ (AC, lunate surface of acetabulum; FH, femoral head.)

Fig 2. Before BST-CarGel application, the lesion is addressed as per the standard procedure. (A) Arthroscopic view of zones II and III of the right acetabulum showing the chondral defect after debridement of delaminated cartilage with a curette. Debridement is performed to expose the subchondral bone and to obtain well-defined, stable margins between the healthy cartilage and the chondral defect. (B) Microfracture of the articular cartilage defect with an arthroscopic awl, penetrating the subchondral bone to a depth of approximately 3 mm, with holes placed every 2 to 3 mm.



wall such as the acetabulum. Before the application, irrigation is stopped and the joint is completely drained of irrigation fluid. Use of a suction cannula and small gauze pad can help to completely dry the treatment surface (Fig 3A). The first layer of the mixture is then delivered in a drop-wise manner using large 18-gauge needles (Smith & Nephew) and without overfilling (Fig 3B). The needles can be bent to ensure full contact with the chondral lesion and to facilitate BST-CarGel delivery. This first layer, even if it is in the antigravity area, will stick in place because of its adhesive properties, sealing the damaged region completely. After this, the clot is constructed by delivering the remaining BST-

CarGel until the damaged area is completely covered (Fig 3 C and D). The mixture volume used per patient varies according to the lesion size. After delivery, the implant clots in place during the required 15-minute waiting period to fully stabilize the implant. A step-by-step summary of this technique is provided in Table 1, and helpful tips are given in Table 2. Key steps of the procedure are shown in Video 1.

Postoperatively, the patient receives simple analgesia and is assessed by a physiotherapist. The patient is discharged on the first postoperative day. Passive motion from the first day and 6 weeks of partial weight bearing (<20 kg) assisted by crutches are recommended

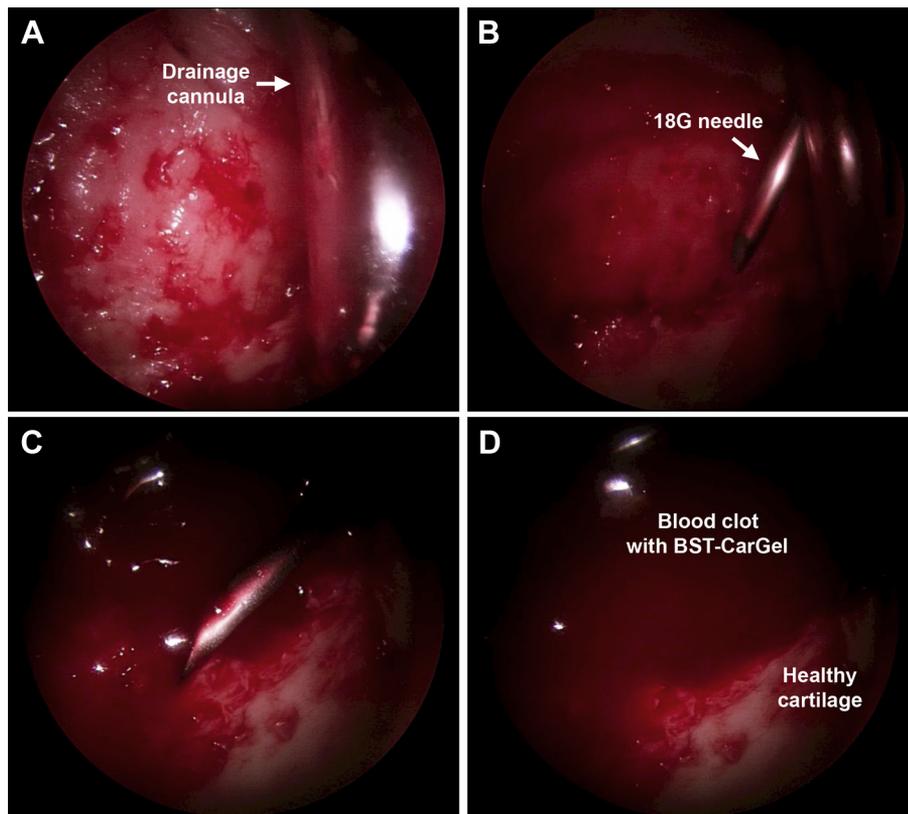


Fig 3. Key steps of BST-CarGel application in previously surgically prepared area. (A) The joint is drained of irrigation fluid using cannulas. (B) The first layer of BST-CarGel is applied in a drop-wise manner using large 18-gauge (18G) needles. (C) Clot construction is performed by delivering the remaining BST-CarGel until the damaged area is completely covered. (D) View of completed repair after BST-CarGel application.

Table 1. Step-by-Step Summary of Arthroscopic Treatment of Hip Chondral Defects With Microfracture and BST-CarGel

Step	Description
1	Position the patient in the supine decubitus position on the traction table.
2	Use the AL portal as the viewing portal and the DMA portal as the working portal.
3	Use a 70° arthroscope and hip arthroscopic set for instrumentation.
4	Perform joint evaluation without fluid and case confirmation for chondral treatment.
5	Set the fluid irrigation pressure at 40 mm Hg with an irrigation pump.
6	Prepare the chondral lesion. Debridement of unstable or pathologic cartilage Debridement of mineralized layer Microfracture
7	Perform labral reconstruction. Pincer resection Acetabular rim trim Placement of labral anchors and labral reattachment
8	Perform osteoplasty for cam lesions. Release of traction T-capsulotomy to access cam deformity Access to medial and lateral plica as usual edges of classic cam deformities Osteochondroplasty Suture of capsulotomy
9	Apply traction to access the central compartment.
10	Stop fluid irrigation and aspiration of articular fluid.
11	Perform complete drying of the chondral defect with small swabs.
12	Release BST-CarGel with bent 18-gauge needles until the lesion is covered.
13	Wait 15 min before releasing traction.

AL, anterolateral; DMA, distal mid-anterior.

in the postoperative period. Low-contact physical activities can be initiated in the third month, whereas high-impact sports must be avoided during the first year after surgery.

Discussion

Microfracture—the deliberate penetration of the subchondral bone below a cartilage lesion to elicit bleeding—is currently the standard of care for the

treatment of limited chondral lesions in the hip joint. Microfracture-induced bone marrow stimulation initiates a repair response that essentially follows the natural wound-healing sequence. BST-CarGel is a first-line cartilage repair option used in combination with bone marrow stimulation that overcomes the major pitfall of standard microfracture, namely the quantity of the initial blood clot present in the cartilage lesion to trigger the wound-healing cascade. The soluble and physiological characteristics of this chitosan polymer solution permit its combination with freshly drawn autologous whole blood to form a hybrid polymer-blood mixture. This mixture can be applied to the cartilage and bone surfaces of prepared lesions, regardless of their geometry and size, to which it adheres and solidifies as a polymer-stabilized hybrid clot.⁴

Animal models have provided extensive evidence supporting BST-CarGel's mode of action. Its use in the treatment of microfractured cartilage defects in adult sheep improved cartilage repair by increasing the amount of filling tissue and improving its biochemical composition and cellular organization. BST-CarGel-repaired tissue contained more cells, with a more chondrogenic phenotype and more type II collagen, when compared with control defects (microfracture only) and showed complete restoration of glycosaminoglycan levels.⁴ Moreover, studies in rabbits highlighted the ability of BST-CarGel to enhance the conventional wound-healing processes during acute and intermediate stages of repair, resulting in increased inflammatory and bone marrow-derived stromal cell recruitment, increased vascularization of the provisional repair tissue, and increased intramembranous bone formation and subchondral bone remodeling. This led to the establishment of more hyaline repair cartilage that was integrated with a porous subchondral bone plate.^{5,6}

BST-CarGel has been successfully applied in patients with knee chondral lesions.⁸ In a recent randomized controlled trial,⁹ 80 patients with a single, symptomatic focal lesion on the femoral condyle were randomized to BST-CarGel and microfracture or to microfracture

Table 2. Tips for and Benefits of Arthroscopic Treatment of Hip Chondral Defects With Microfracture and BST-CarGel

Tip	Benefit
Work with low-fluid pressure (40-60 mm Hg).	Facilitates drying of area before implanting BST-CarGel
Alert the anesthetist to work with low tension (systolic blood pressure <70 mm Hg).	Facilitates drying of area before implanting BST-CarGel
Work with 60°-90° sharp awl.	Provides perpendicular holes and consequently avoids scratches and hole connection
Apply BST-CarGel as the last step during the articular repair process in the central compartment and before moving to the peripheral compartment.	Reduction of the surgery time before BST-CarGel implantation diminishes fluid extravasation into the soft tissues and therefore facilitates the posterior drying process.
Use air infusion cannulas through the accessory portal and aspiration through the lateral portal to obtain continuous air flow.	Improves drying process
Use neurosurgery swabs during the drying process.	Neurosurgery swabs can be easily introduced through the cannula and are less susceptible to being lost intra-articularly.
Use long and malleable needles to release BST-CarGel.	Facilitates drop-wise delivery of implant even in antigravity area

treatment alone. At 12 months, BST-CarGel treatment resulted in statistically significantly greater lesion filling and superior repair tissue quality compared with microfracture treatment alone, with similar safety profiles for both groups.

In this report we describe an arthroscopic technique to perform BST-CarGel application in the hip. Our preliminary data suggest that this cartilage repair option represents a safe, cost-efficient improvement over the standard hip microfracture technique alone and is technically feasible. Nevertheless, the long-term outcome is still unknown and these results need to be further confirmed by long-term clinical studies.

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