

Nanofracture:

A New Technique for Improved and Systematic Deep Marrow Stimulation and Subchondral Bone Protection

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Articular cartilage is an avascular, hypocellular tissue with dense collagen fibrils and a protein matrix that provides a low-friction and highly durable wear resistant surface. The complex composition of hyaline cartilage is maintained by chondrocytes residing in the cartilage matrix which contains 90-95% Type II collagen. The collagen fibrils and matrix proteins together form a unique tissue that regulate water content (75% of hyaline cartilage), lubrication, and tensile strength to resist mechanical wear⁸.

Following injury or degeneration, the avascular nature and relative low cell count of articular cartilage prevent a repair response that restores the normal architecture of cartilage, however, when stimulated by subchondral bone perforations, pluripotent marrow derived mesenchymal cells are attracted into the cartilage defect and trigger a remodeling and repair process. The lasting effect of the procedure is highly dependent on the defect fill and the cartilage quality. Fibrocartilage (majority type I collagen) elicits a scar type healing as opposed to hyaline cartilage (majority type II collagen) which recreates the normal anatomy.

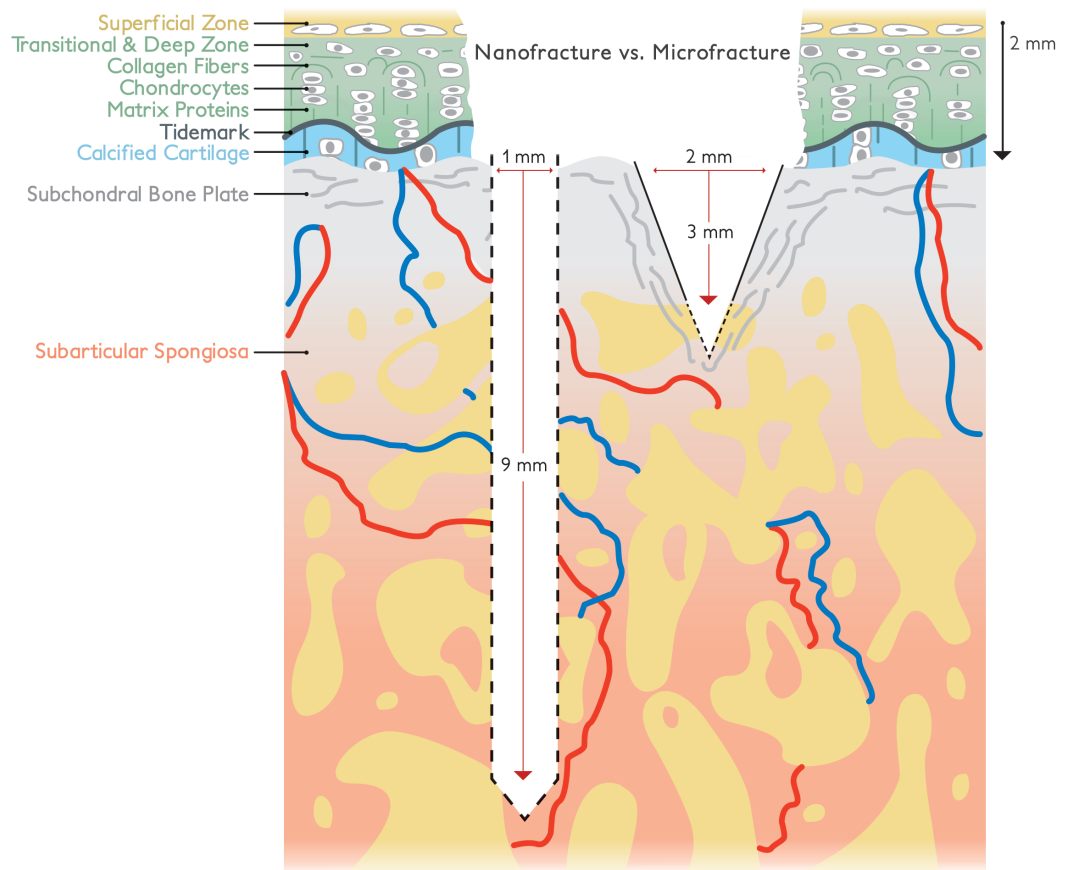
Nanofracture vs. Microfracture

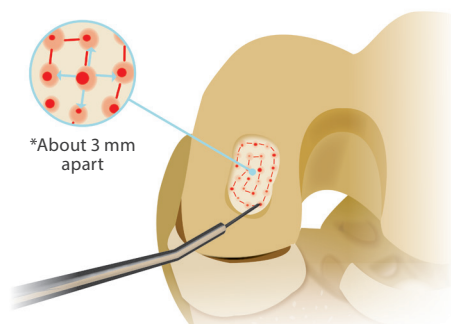
- Deeper bone marrow access compared to shallower holes elicited
 - Greater volume fill of the defect
 - More hyaline character
 - More type II collagen
 - Less type I collagen
- Chen et al. J Orthop Res. 2011*

- Increased marrow access and bone remodeling correlated with improved cartilage resurfacing properties.
- Chen et al. Am J Sports Med. 2011*

- 2mm deep Microfracture with an awl induced fracturing and bone compaction around holes that were largely sealed off from adjacent bone marrow.
- Chen et al. J Orthop Res. 2009*

- Nanofracture needle tip
 - Remains sharp
 - Provides better control for placement of systematic perforations
 - Avoids slippage and damage to healthy cartilage





Surgical Technique:

Begin by debriding the superficial calcified layer. Nanofracture is performed in a systematic spiral fashion starting from the periphery of the lesion: The 1mm thick needle (Nitinol) is inserted into the lumen of the cannulated pick and advanced to the laser line. The pick is placed onto the defect bed and multiple light strikes on the proximal end advance the needle tip into the subchondral bone at a consistent, stop controlled depth of 9mm without creating thermal damage. Nanofracture Picks come with a 15° tip to facilitate defect access. Literature recommendations space each perforation about 3mm apart to give an even pattern. Adequate bone bridges between each channel have to be maintained to protect the mechanical stability of subchondral bone during postop remodeling. A joint lavage concludes the procedure to remove loose bony particles and cartilage debris. Intraarticular drains should not be used to avoid interference with marrow clot formation, cell recruitment and differentiation^{5,6,7}.

References:

1. Buckwalter JA, Mankin HJ. Articular cartilage: degeneration and osteoarthritis, repair, regeneration, and transplantation. *Instr Course Lect.* 1998;47:487-504. Review.
2. Chen H, Hoemann CD, Sun J, Chevrier A, McKee MD, Shive MS, Hurtig M, Buschmann MD. Depth of Subchondral Perforation Influences the Outcome of Bone Marrow Stimulation Cartilage Repair. *J Orthop Res* 29(8):1178-1184, 2011.
3. Chen H, Sun J, Hoemann CD, Lascau-Coman V, Ouyang W, McKee MD, Shive MS, Buschmann MD. Drilling and microfracture lead to different bone structure and necrosis during bone-marrow stimulation for cartilage repair. *J Orthop Res.* 2009 Nov;27(11):1432-8.
4. Chen H, Chevrier A, Hoemann CD, Sun J, Ouyang W, Buschmann MD. Characterization of subchondral bone repair for marrow-stimulated chondral defects and its relationship to articular cartilage resurfacing. *Am J Sports Med.* 2011 Aug;39(8):1731-40.
5. Gomoll AH, Filardo G, de Girolamo L, Espregueira-Mendes J, Marcacci M, Rodkey WG, Steadman JR, Zaffagnini S, Kon E. Surgical treatment for early osteoarthritis. Part I: cartilage repair procedures. *Knee Surg Sports Traumatol Arthrosc.* 2012 Mar;20(3):450-66.
6. Mithoefer K, McAdams T, Williams RJ, Kreuz PC, Mandelbaum BR. Clinical efficacy of the microfracture technique for articular cartilage repair in the knee: an evidence-based systematic analysis. *Am J Sports Med.* 2009 Oct;37(10):2053-63.
7. Mithoefer K, Williams RJ 3rd, Warren RF, Potter HG, Spock CR, Jones EC, Wickiewicz TL, Marx RG. Chondral resurfacing of articular cartilage defects in the knee with the microfracture technique. Surgical technique. *J Bone Joint Surg Am.* 2006 Sep;88 Suppl 1 Pt 2:294-304.
8. Ulrich-Vinther M, Maloney MD, Schwarz EM, Rosier R, O'Keefe RJ. Articular cartilage biology. *J Am Acad Orthop Surg.* 2003 Nov-Dec;11(6):421-30. Review.

Patient Profile and Outcomes Predictors

Factors	Better Results With
Age ⁶	< 40 years
Duration of symptoms ⁶	< 12 months
Lesion size ⁶	Up to 2 x 2 cm
Lesion depth ⁶	< 5 mm
Body mass index ⁶	<30 kg/m ²
Preoperative activity level Tegner score ⁶	> 4 (better with higher preop activity levels)
Previous surgery ⁶	Primary microfracture
Repair cartilage volume ⁶	Good defect fill (>66%)
Mechanical alignment ¹	Normal
Joint anatomy ¹	Normal
Joint stability ¹	Ligamentously stable with adequate muscle strength
Meniscus	Normal without loss of meniscal tissue

Rehabilitation:

Pluripotential stem cell stimulation is one of the few arthroscopic concepts where the treatment effect is triggered intraoperatively and the actual repair is developed during postoperative rehabilitation. Weight bearing restrictions are not only important for articular cartilage repair, but also for protection of the subchondral bone after microfracture during the first 6-8 weeks. Premature weight bearing can lead to displacement of the repair clot, inferior tissue integration, and can impact subchondral bone remodeling. Patient and therapist compliance is therefore critical. For knee rehabilitation⁵, CPM is started immediately for 6-8 hrs/day with ROM from 30°-70°. Gradual increase by 10-20% is continued until full passive ROM is achieved. Toe-touch weight bearing (10% initially, progressed to 20-30% max) is maintained for 6-8 weeks. Patella mobility exercises, quadriceps sets, straight leg raises, hamstring stretching, and ankle pumps are also initiated on day 1. Stationary biking without resistance and deep water exercises are initiated at 1-2 weeks postoperatively. After 8 weeks, patients are progressed to weight bearing as tolerated. Restoration of normal muscular function using low-impact exercises is emphasized during weeks 9-16. Return to sport involving pivoting, cutting, or jumping is not recommended for at least 4 - 9 months.

Conclusion:

Technical aspects, such as defect preparation, deep and standardized subchondral cell recruitment without thermal damage, consistent pattern, and small needle diameter provide a systematic and protective approach to pluripotential stem cell stimulation. Postoperative follow-up is critical for remodeling of the entire osteochondral architecture.

Always refer to the package insert information, product labeling and/or user instructions before using any Arthrosurface product.

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