CLINICAL MONOGRAPH

NanoFx

Bone Marrow Stimulation in Cartilage Repair: Comparing Microfracture, Nanofracture, and K-Wire Perforations

W.R. Walsh, Ph.D., N. Bertollo, Ph.D. , D. Schaffner, M.D., R. Oliver, Ph.D. , C. Christou, B.ScVet

Surgical & Orthopaedic Research Laboratories (SORL), Prince of Wales Clinical School
The University of New South Wales, Sydney, Australia 2031

Introduction

- Attracting precursor cells into the defect of cartilage lesions through bone marrow stimulation has been a popular treatment option in cartilage repair. Since the late 1980s, microfracture has developed into the primary procedure of choice due to its low cost nature, relative low morbidity, and encouraging results as a primary cartilage procedure, especially in young and active patients (1-3).
- Renewed interest into subchondral bone effects shed new light into microfracture's limitations: Shallow channels, wall compression, and an increase in trabecular thickness and density have been demonstrated on microCT and histology (4-6). Chen et al. reported that deeper subchondral bone stimulation yielded better cartilage fill, higher collagen Type II content and less Type I when compared to shallow bone marrow access (5).
- The non-standardized depth, diameter, and perforation density of microfracture lead to the development of a new subchondral bone perforation procedure (nanofracture) that reaches to a standardized depth of 9mm deep at a width of 1mm.
- An ethics approved adult ovine model shed light into the subchondral behavior of three marrow stimulation methods and their effects on the trabecular channel structure.
- Based on a recent article from Eldracher et al. (7), 1.0mm drill holes showed improved histology, subchondral bone reconstitution and immunoreactivity to type 2 collagen when compared to 1.8mm wide channels. (Figure 4A, B)

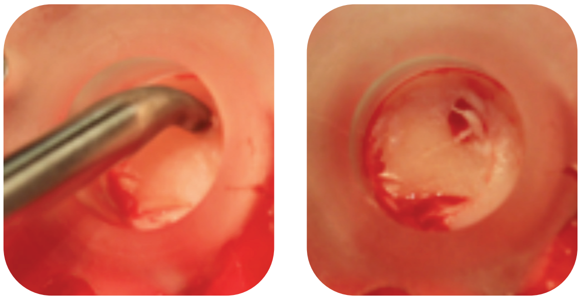


Figure 2A,B: *Low in-vivo response with moderate bone marrow flow after microfracture*

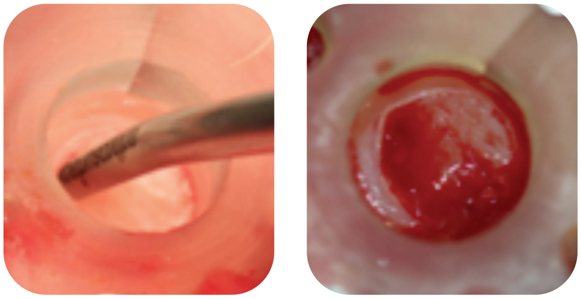


Figure 3A,B: *High in-vivo response with significant bone marrow flow after nanofracture*

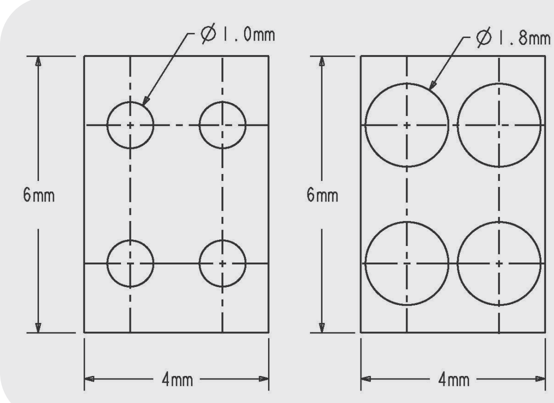


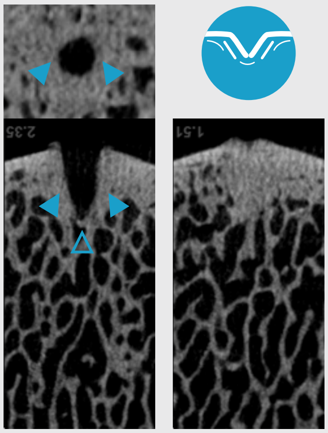
Figure 4A,B: *Scale drawing of 1mm vs 1.8mm drill holes.*

Subchondral Response to Marrow Stimulation

Figure 1A,B,C: *Color coded Microfracture awl (diameter: ~2.5mm) (left), Nanofracture (diameter: 1mm) (center), K-Wire (diameter: 1mm) (right)*

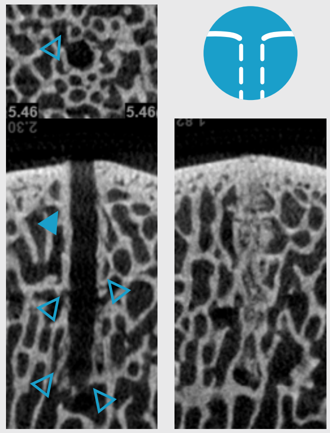
Clinical Monograph

Figure 5 A,B,C: △ *open trabecular channels;* ▲ *closed trabecular channels, microCT comparison: Axial (top), Sagittal (bottom).*



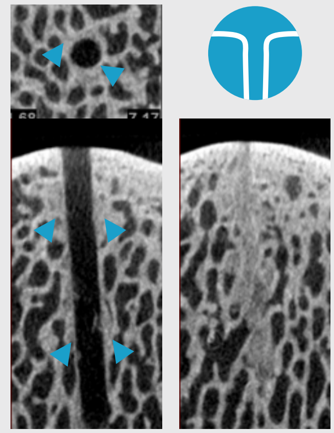
5A

Microfracture (5A): Trabecular wall thickness and density increased by apparent bone compression; limited trabecular channel access; channel borders with non-anatomic regularity; microfracture channel margins: Dense, compressed bone deposit (right).



5B

Nanofracture (5B): Trabecular wall thickness and density appears normal; large number of open trabecular channels; anatomic irregularity of trabecular channel borders intact; nanofracture channel margins: Course and fragmented trabecular bone deposits (right).



5C

1mm K-Wire (5C): Trabecular wall thickness and density close to normal; limited trabecular channel access; channel borders with non-anatomic regularity; k-wire channel margins: Pulverized and dense osseous deposits (right).

Summary

- Microfracture elicited shallow depth with bone compression extending into cancellous bone. Trabecular channel access is limited; the channel depth and diameter are highly variable and the technique is user and instrument dependent.
- Nanofracture demonstrated deep cancellous bone perforation with a high number of open trabecular channels. The procedure is standardized with a stop controlled depth of 9mm with a diameter of 1mm.
- K-Wire drilling resulted in well defined channel walls, however, trabecular channel access was limited. The diameter of the wire is standardized, but depth is highly variable as it is visually controlled.

Conclusion

Nanofracture resulted in thin, open cancellous bone channels without rotational heat generation. Compared to microfracture and K-Wire stimulation, NanoFx showed superior bone marrow access with multiple trabecular access channels extending 9mm into subchondral bone. As seen from the recent data, small 1mm wide channels improve osteochondral repair and the reconstitution of the subchondral bone plate & sub-articular spongiosa.

1. Kreuz PC, Steinwachs MR, Erggelet C, Krause SJ, Konrad G, Uhl M, Südkamp N. Results after microfracture of full-thickness chondral defects in different compartments in the knee. Osteoarthritis Cartilage. 2006 Nov;14(11):1119-25. **2.** Mithoefer K, Williams RJ 3rd, Warren RF, Potter HG, Spock CR, Jones EC, Wickiewicz TL, Marx RG. The microfracture technique for the treatment of articular cartilage lesions in the knee. A prospective cohort study. J Bone Joint Surg Am. 2005 Sep;87(9):1911-20. **3.** Steadman JR, Briggs KK, Rodrigo JJ, Kocher MS, Gill TJ, Rodkey WG. Outcomes of microfracture for traumatic chondral defects of the knee: average 11-year follow-up. Arthroscopy. 2003 May-Jun;19(5):477-84. **4.** 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. **5.** 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. 2011 Aug;29(8):1178-84. **6.** Fortier LA, Cole BJ, McIlwraith CW. Science and animal models of marrow stimulation for cartilage repair. J Knee Surg. 2012 Mar;25(1):3-8. **7.** Eldracher M. et al. Small Subchondral Drill Holes improve Marrow Stimulation of Articular Cartilage Defects. Am J Sports Med. 2014 Nov;42(11):2741-50.

Anika Therapeutics, Inc.
28 Forge Parkway, Franklin, MA 02038
1-888-721-1600 | customerservice@anika.com
www.anika.com | Anika. Restore Active Living.® | Stay Active®

AML-900-705 REV 01

ANIKA arthrosurface