MRI and Quantitative T2 mapping of Cartilage Repair Using Synthetic Biphasic Acellular Scaffold

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Introduction: The inherent inability of cartilage for spontaneous repair has lead to development of surgical and biologic methods of inducing a structurally durable repair response. Synthetic biphasic acellular plugs are a composite material of polylactide-co-glycolide (PLG) co-polymer, with the cartilage phase reinforced by polyglycolic acid fibers, and the addition of calcium sulfate to the bone phase to enhance bone ingrowth. Its use obviates the need to harvest autologous or allograft osteochondral plugs or chondrocytes for culture. Animal studies (1) have shown that osteochondral lesions treated with these acellular resorbable implants repaired with well integrated hyaline-like cartilage and good underlying bone, with no significant difference in healing with constructs that contain chondrocytes. The purpose of this observational study is to describe the short term appearance of the plugs using cartilage sensitive MRI and quantitative T2 mapping, which has been shown to correlate to the integrity of collagen in the extracellular matrix of cartilage repair models (2).

Methods: 42 patients (a total of 173 plugs) who had undergone synthetic plug implantation in the knee and post operative MRI were prospectively identified from our institution's cartilage repair registry. Follow up period range from 1.7 to 27.5 months (mean 5.3 months). These were divided into 4 time frames: 1) 0-3 months; 2) 3-6 months; 3) 6- 12 months and 4) over 12 months. 14 of these patients (30 plugs) had serial MRI. Morphologic evaluation included signal intensity of both phases, morphology, percent fill, intensity of surrounding edema, native-repair interface, ICRS grade of the cartilage and subjective assessment of osseous incorporation. 127 of these plugs had corresponding quantitative T2 mapping using a modified CPMG pulse sequence (3).

Results: 0-3 months: Just over one third (23/59) of the plugs were depressed relative to adjacent bone and cartilage, with mild to moderate subchondral edema, poor bony incorporation and hyperintense articular phase relative to native cartilage.

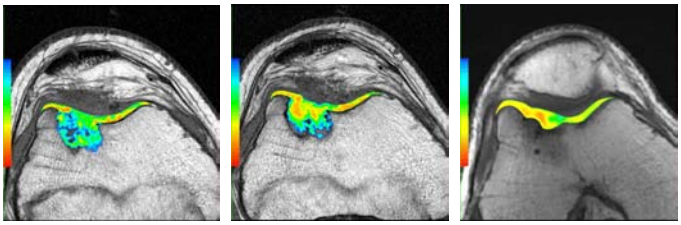
3-6 months: Over half (38/70) were depressed relative to adjacent bone and cartilage, but with progressive bone incorporation compared to the shorter term follow up, with persistent hyperintensity in the articular phase.

6-12 months: The majority of the plugs (19/29) appeared flush with regards to morphology with decreased intensity of the bone marrow edema pattern. There was progressive peripheral integration of the cartilage phase with the native hyaline cartilage.

>12 months: Progressive maturation of the signal characteristics was noted with minimal residual marrow edema and markedly improved bony incorporation surrounding the plug. Progressive fill and T2 shortening was observed, particularly in the plugs noted at the periphery of repair.

	0-3 mo (n=43)	3-6 mo (n=51)	6-12 mo (n=18)	> 12 mo (n=15)
% T2 diff. of central plug vs. normal cartilage	67	59	37	33
% T2 diff. of peripheral plug vs. normal cartilage	47	40	16	14

Table: Differences in T2 values of cartilage phase of synthetic implant compared to normal cartilage.



8 month 13 months 27 months

Figure: Quantitative T2 relaxation time maps demonstrate progressive bony incorporation and fill of the articular phase of the synthetic implants.

Discussion and Conclusion: The resorbable biphasic synthetic implants demonstrate variable signal intensities on short term follow up that may simulate plug failure and apparent delayed biologic incorporation. Progressive subjective peripheral osseous incorporation is observed over time. T2 values of cartilage phase demonstrate initial prolongation suggesting an immature matrix, with shortening over time. After 6 months, the T2 profile was close to that of the adjacent cartilage, indicating maturation of repair to a more organized extracellular matrix. This was more notable in the periphery of the plugs. The results indicate progressive ingrowth of hyaline-like tissue from the peripheral margin of these constructs. Further long term follow up with assess ultimate longevity of this repair tissue.

References:

1) Niederauer GG, Slivka MA, Leatherbury MC, Korvick DL, Harroff HH Jr, Ehler WC, Dunn CJ, Kieswetter K. Evaluation of multiphase implants for repair of focal osteochondral defects in goats. Biomaterials 2000; 21: 2561-2574
2) Glenn RE Jr, McCarty EC, Potter HG, Juliao SF, Gordon JD, Spindler KP. Comparison of fresh osteochondral autografts and allografts: A canine model. Am J Sports Med 2006; 34(7):1084-1093.
3) Maier CF, Tan SG, Hariharan H, Potter HG. T_2 quantitation of articular cartilage at 1.5T. J Magn Reson Imaging 2003; 17(3):358-364.