# Can a 3D printed Nanochon Chondral Implant result in repair tissue grossly, histologically and biomechanically improved compared to empty defects in full thickness cartilage lesions?

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Disclosures: Ben Holmes and Nathan Castro are the co-founders of Nanochon.

**Introduction:** Articular cartailge lesions represent a significant clinical challenge and the development of a treatment that enables restoration of the joint surface with tissue biomechanically identical to articular cartilage is highly sought after. Chondrograft™ is a novel 3D printed porous implant composed of nanomaterials that fosters host integration, designed for use in cartailge repair. The objective of this study was to validate the use of the Chondrograft™ Implant for the treatment of full thickness cartilage lesions, assessing its ability to fill the defect and support the engraftment of repair tissue to the underlying subchondral bone. The first hypothesis was that Chondrograft™ will fill the full thickness cartilage defect and induce superior repair tissue to the untreated control. Our second hypothesis was that the Chondrograft™ will perform better in biomechanical testing compared to untreated controls.

**Methods**: Bilateral 15mm diameter cartilage defects were created on the lateral trochlear ridge of the femur in 12 mature horses, 6 males and 6 females (IACUC approval 3171). One defect was implanted with Chondrograft™, which was positioned flush with the cartilage surface, and held in place with fibrin glue and a single PLLA dart (Arthrex Trimit Pin). The contralateral limb was an untreated (empty/full thickness) control defect. Horses were exercised starting day 28 and end points were at 36-weeks (4 horses) and 52-weeks (8 horses). Lameness examinations were performed every 4 weeks and recheck arthroscopic evaluation was performed at 12 weeks. Post-mortem evaluation included arthroscopic and macroscopic appearance scoring, MRI, histological assessment and biomechanical testing. Lameness, MRI MOCART scores and data relating to ICRS scores were assessed for normality, following which a t-test (parametric) or Mann-Whitney test (non-parametric) was performed. Mechanical testing data was assessed with a two-way ANOVA with Tukey's post-hoc test to determine statistical significance for stiffness comparing treatment groups and location.

**Results**: Lameness scores were not statistically different between Chondrograft™ and control limbs at any time points. The 12-week follow-up arthroscopy revealed the Chondrograft™ treated defects had a mean repair tissue fill of 99.17 ± 1.946% compared to 45.83±33.70% in the control group ($P < 0.0001$). Post-mortem arthroscopic ICRS scores for defect fill and border attachment to surrounding cartilage were improved in the Chondrograft™ treated defects (3.5 ± 0.67 and 3.25 ± 0.97 respectively) compared to the control defects (2 ± 1.13 and 1.83 ± 1.19) ($P = 0.0016$ and $P = 0.0068$). The overall arthroscopic ICRS score of the Chondrograft™ treated defects were 9.67 ± 2.31 compared to controls 4.83 ± 2.7 ($p = 0.0001$) (Figure 1). Histological O'Driscoll scores were significantly higher (improved) in the Chondrogaft treated defects compared to controls (35.2 vs 28.2)($P=0.02$) (Figure 1) and they also had higher collagen type 2 scores compared to controls (12.6 vs 8.6). Biomechanical testing revealed significantly higher repair tissue stiffness in Chondrograft™ treated defects compared to controls ($P<0.0001$)(Figure 2).

**Discussion**: In concordance with our hypothesis, Chondrograft™ successfully filled a full thickness cartilage defect and provided repair tissue that was grossly and histologically improved over repair tissue from empty defects. Our second hypothesis was also confirmed in that the Chondrograft™ was biomechanically superior to control defects. The Chondrograft™ treated defect had improved repair tissue fill compared to the control group, as well as a much smaller standard deviation representing reduced individual variability. A further benefit of Chondrograft™ is its ability to become incorporated with the surrounding cartilage. This is evidenced by the MOCART MRI scores and the ICRS scores. This incorporation is important to help reduce biomechanical and structural deterioration of the repair tissue over time due to exposure to shear forces. A limitation of this study is the potential role of the fibrin glue in providing growth factors encouraging repair in the Chondrograft™ treated group may have contributed (to a small degree) to the improved healing as fibrin glue was not used within control defects.

**Significance**: Chondrograft™ results in excellent defect filling and integration to the surrounding cartilage, with biomechanical function similar to normal healthy articular cartilage. The Chondrograft™ implant appears to be a viable option to improve cartilage defect healing.

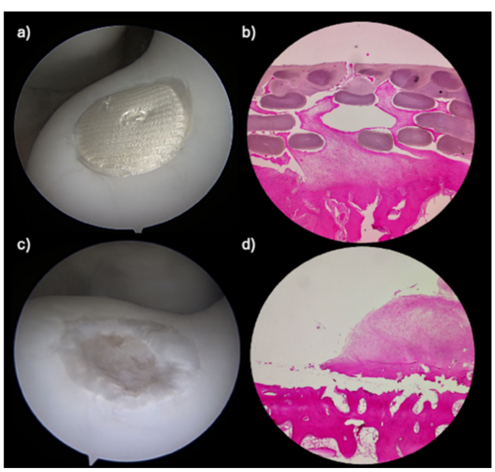


**Figure 1**. Arthroscopic images of the Nanochon 3D printed implant in a 15mm full thickness cartilage defect or a 15mm control/empty full thickness cartilage defect, with corresponding histology A + C) Endpoint arthroscopic evaluation at 52 weeks. B + D) Corresponding histology.

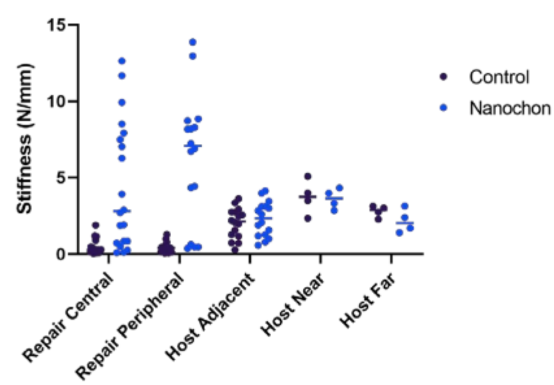


**Figure 2.** Dot plot to show the mean stiffness of Nanochon Chondrograft™ and control repair tissue.