Automated Planning of Computer-Guided Mosaic Arthroplasty

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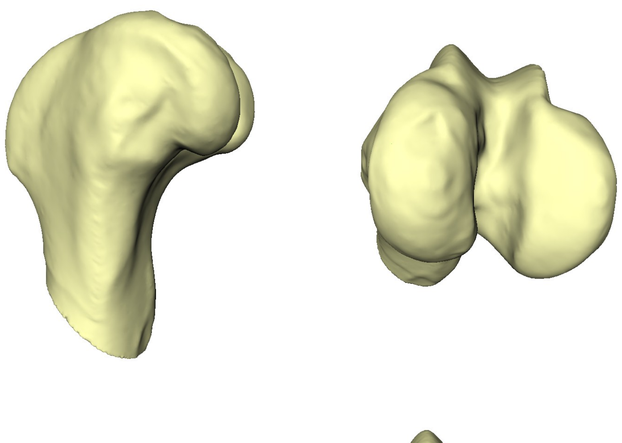
I. Introduction

- Computer-guided mosaic arthroplasty requires a plan for choosing and placing several osteochondral grafts on a computer model of the joint.
- Plans can be created by an expert human using a computer to manually position and orient each plug's harvest location and recipient location. This is a time consuming manual method.
- We investigated whether a computer algorithm could achieve reconstruction plans as good as those of an expert human.

II. Automated Method

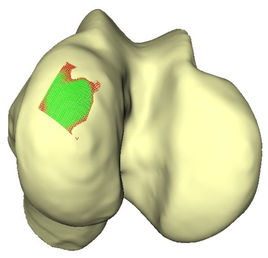
The Data

Surface mesh models from 12 sheep knees in original condition and three months after an impact-induced cartilage defect.



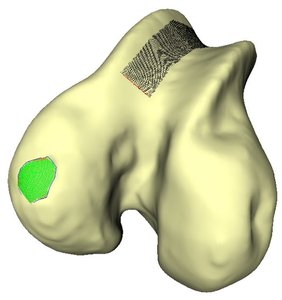
Spline approximation

A human operator places 4 control points on the bone mesh to generate a spline surface, which predicts the original cartilage surface.



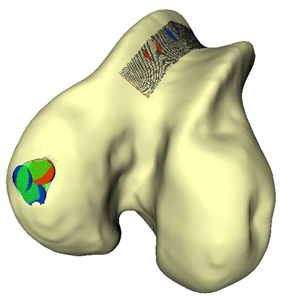
Outlining

The defect is then outlined on the spline surface. The potential donor region is also outlined on the mesh surface.



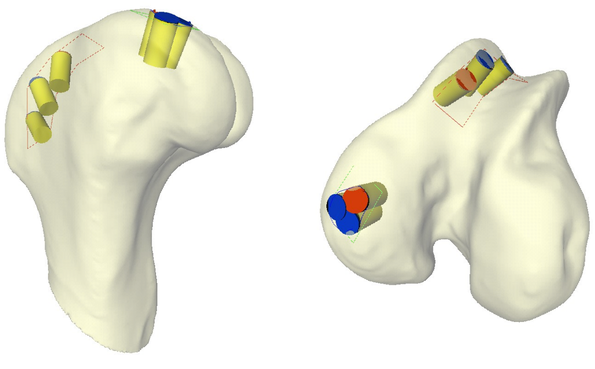
Graft Selection

The computer algorithm determines a pattern of grafts to cover the defect site and searches the donor region for matching grafts.



The Plan

A plan consists of donor and placement sites for two to five osteochondral grafts.



III. Expert Human Method

- Manual selection and placement of cartilage crafts using a computer interface.
- Grafts could be positioned and oriented and had their cartilage surface tilted to match the surface at the donor site.
- The expert human operator reported planning times of approx. 20 minutes per case.

IV. Results

Planning Results

Case #	Manual RMSE (mm)	Automated RMSE (mm)	Automated Time (sec)
1	0.16	0.13	87
2	0.09	0.15	266
3	0.61	0.36	299
4	0.25	0.20	153
5	0.23	0.29	146
6	0.36	0.21	77
7	0.24	0.28	355
8	0.16	0.27	169
9	0.48	0.26	441
10	0.43	0.38	344
11	0.32	0.38	291
12	0.36	0.13	624
mean	0.31	0.25	271
95% CI	(0.23, 0.37)	(0.20, 0.30)	(181, 361)

- The RMS errors between the planned repair surfaces and the original, uninjured surfaces were computed using the same methodology for both human and automated cases.
- Planning times for the automated method were also recorded.
- The automated method had mean RMS error of 0.25 mm (95% CI: 0.20-0.30, min 0.13, max 0.38) and took about 4.5 minutes. The expert human achieved mean RMS error of 0.31 mm (95% CI: 0.23-0.38, min 0.09, max 0.61) and took twenty minutes.

V. Conclusions

- No statistically significant difference in RMS error between the algorithm and the expert.
- The algorithm was faster and produced surfaces with less variance.

Presented at the 9th World Congress of the International Cartilage Repair Society in Sitges - Barcelona, Spain, September 26 - 29, 2010

This research is supported by NSERC Strategic Grant #336797