MENISCAL REPAIR WITH A NEW BIOLOGIC GLUE

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Introduction:
Knee meniscal injury is a very common disorder. Meniscectomy leads to degenerative arthritis of the knee. Great efforts have therefore been directed towards preserving as much of the meniscus as possible. Current meniscal repair techniques employ sutures or staples, however biological adhesives have also been utilised. These adhesives have the theoretical advantage of minimising the gap and providing full contact of the bonded surfaces, which may in turn aid repair. The aim of this study was to compare the mechanical strength of four different adhesives including a novel compound secreted by a species of frog in Australia using a meniscal tear propagation method.

Methods:
Sample preparation: Fresh medial menisci (n=48) were dissected from intact sheep joints. A longitudinal cut was created 3 mm away from the meniscal periphery which extending from the posterior horn to the anterior horn, leaving a 1.5 cm anterior region intact. Holding sutures were inserted into the free ends of the meniscal fragments.

The following adhesives were tested:
1. Fibrofix (Beriplast HS; fibrinogen/thrombin, Centeon Pharma GmbH),
2. Gelatine (GRF Biological Glue; gelatine/resorcin/formaldehyde, Implants Chirurgicaux),
3. Frog glue (new, naturally-sourced, non-toxic glue),

The adhesives were prepared according to their specifications and applied to one side of the meniscal cut surface. The fragments were pressed firmly together for a period of time depending on the requirement for the glue. The glued samples were incubated in wet conditions at room temperature for 24 hours.

Mechanical testing: To simulate the mechanism of the naturally occurring meniscal injury, a tear propagation method (ASTM D 1876-95 standard) was used to determine the peel strength (average load required to separate the bonded fragments per unit width of bondline) of each adhesive. The free ends of the meniscal fragments were attached to the load cell of a Shimadzu AG-50kNE tensile testing machine, and a constant rate of distraction (40 mm/min) was applied. Force and displacement data were collected throughout the entire tear test and saved to computer. After mechanical testing the previously glued surfaces were digitized and the total area of the glued region was determined using image analysis software. A standard tear length (30mm) was set over the range between the tear initiation peak and loading of the uncut meniscus. The peel strength was determined for each individual sample by dividing the average force calculated over a standard tear length (Figure 1) by the average width of the sample. The test group means were compared using ANOVA. Data is presented as means ± SEM.

Results:
In all cases, tearing occurred along the tissue-adhesive interface. Cyanoacrylate formed a hard, brittle film on the glued surfaces, while the other glues remained rubbery. The average peel strength of the adhesives are shown on Figure 2. The strongest bond was made by the cyanoacrylate glue, followed by the frog glue. The frog glue was found to be five times stronger when compared with the fibrin glue, and two and half times stronger than the gelatine glue. There was a statistically significant difference between each group (p<0.0001), except between the gelatine and fibrin glues (p=0.6).

Conclusions:
The tear propagation method for mechanical testing of meniscal repair provided consistent and reproducible data. Cyanoacrylate glue provided the strongest bond, however it is considered to be toxic, and recommended for minor skin wounds only. Gelatine and fibrin glues, which are used in clinical practice to augment sutures by providing a “sealant” effect, were not particularly strong. The frog glue, while not commercially available yet, demonstrated superior mechanical strength over the other two biological glues, and with its sealant characteristics, makes this adhesive attractive for future applications.

Acknowledgment: A special thanks to Prof. Mike Swain (Biomaterials Science Research Unit, Australian Technology Park) for his expert advice. This study was supported in part by St George Private Hospital / Health Care of Australia.

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Figure 1: Force versus displacement plot for a meniscal peel test (Sample 1). The initial peak is due to the initiation of the glue line fracture, while the final rapid increase in force is due to the response of the intact meniscus. The dashed line represents the average force determined over a standard tear length.

Figure 2: Peel strength of surgical adhesives on medial menisci using tear propagation method. (Mean with SEM. *** = p<0.0001, n = number of samples)