Introduction:

Trabecular materials are currently being developed as a means to augment soft-tissue attachment to prosthetic implants. Current work on soft tissue in-growth with these materials is very promising. In a simple canine model, bulk blocks of the trabecular metal were shown to be completely ingrown by four weeks when placed in the subcutaneous tissue and subsequent studies looking at bone in-growth including work with canine acetabular components have been equally compelling. While this early work has shown great promise, what remains unclear in the literature is the potential existence of any key variables with respect to soft tissue in-growth. Specifically, does an optimal pore size in foam structures exist with respect to enhancing soft tissue in-growth and its strength?

Method:

Porous alumina ceramic implants of fixed porosity (~ 85%) were designed in three pore size ranges (150-175 (Small), 240-400 (Medium) and 600-800 (Large) µm). Using an established canine model, six implants (two of each type) were implanted in the dorsal subcutaneous tissues of 12 mature canines resulting in a sample size of 72 implants. The implants were removed at 4, 8 & 16 weeks. Peel testing was performed using a servo-hydraulic testing machine (MTS, Minneapolis, MN), in which a distraction force was applied to the ingrown tissue at a rate of 5 mm/minute. The attachment force was measured with a 25 N load cell and was performed to progressively peel the soft tissue from the surface of the implant for a total distance of about 10 mm. The point where the force deviated from linearity was defined as the yield point. The average force over the subsequent 10 mm of distraction was calculated and reported as the peel strength. Specimens were then prepared for subsequent histological analysis. The capacity for in-growth of these foam implants was determined based on gross examination and the percentage of in-growth noted on histomorphological analysis.

Results:

With peel testing, no significant difference was observed in mean yield force among the three time periods (p=0.49), however pore size was observed to significantly affect yield force; the mean yield force of the large pore size (9.6 N) was significantly larger than the mean yield force of both the medium pore size (7.2 N) and the small pore size (5.9 N), p=0.004. In the 10 mm average yield force, duration of implantation was not found to be statistically significant (p=0.62) but once again, pore size was observed to significantly affect average force of peeling over 10 mm. The mean force of the large pore size (10.8 N) and the medium pore size (8.5 N) were significantly larger (p=0.001) than the mean force of the small pore size (5.9 N) (Fig. 1).

Gross inspection of all the implants determined that at all time points, the implants had been completely grown in with soft tissue. There were numerous, sizable blood vessels visible to the naked eye on both the surface and within the matrix of the implants (Fig. 2). Histological analysis revealed, all pore sizes were filled with soft tissue in-growth exceeding 95% by volume (Fig. 3), there was no evidence of infection, inflammation or incompatibility with the implants in any of the test subjects and there were numerous blood vessels noted coursing throughout the specimens.

Discussion:

This study suggests that architecture of porous foam structures in general, and not the type of material used, confers the biologic activity and that there is a wide tolerance for pore size in facilitating this process in soft tissue in-growth with attachment strength found to increase with pore size. These results demonstrate that this genre of material has a very unique potential to provide rapid, stable, vascularized soft tissue in-growth that will be of tremendous potential benefit to the challenges and goals of orthopaedic reconstruction in the primary, revision and oncologic setting. Further study of other inert porous structures will be useful in further defining the assets and limitations of trabecular materials as a whole.

References:


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