ARTIFICIAL INTERVERTEBRAL DISC FOR CHILDREN SYNTHETIC SPINE

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Introduction

This paper aims to develop an artificial intervertebral disc (AID) for children synthetic spine to replicate the movement of the human spine for spinal testing. The IVD is an anisotropic structure, which allows both elasticity and stiffness and although the IVD subjected to variety of forces and moments the most prevalent force is compression. The IVD varies in height and area between the spinal region, age and gender. Children IVD is more hydrophilic than the adult hence give more flexibility [Clark et al, 2001]. The objective of this study is to identify which combination of factors best represents the children disc by comparing the compression stiffness and modulus of the AID with published data.

Methods

The design for AID was made to compliment the shape of the children vertebra model using Creo Parametric 1.0. The disc height was fabricated twice the size from the actual design to suit the size of the synthetic model. The materials used were monothane with A-70 hardness for annulus fibrosus (AF) and endplates for ease of manufacture and silicone rubber with A-40 hardness for nucleus pulposus (NP). Three factors considered were the disc height (A), the percentage volume of AF (B) and type of silicone rubber for NP (C). The experiment was carried out under load control to up 800 N at a rate of 3.3 N/s based on [Hawkins et al, 1995].

Run Order	A (mm)	B (%)	C (MPa)	Average Modulus (MPa)
6	6	40	0.62	12.97
8	6	40	1.31	15.63
1	8	40	0.62	10.33
4	8	40	1.31	12.47
2	6	50	0.62	12.03
5	6	50	1.31	12.97
3	8	50	0.62	9.93
7	8	50	1.31	11.40

Table 1: Average results from 8 design points.

Results

The results were obtained from 8 design points and three replications. (Refer Table 1) The results were analysed using MiniTab 11. By taking significance p-values at values less or equal to 0.01, all factors and two ways interaction (AC and BC factors) showed significant effects. AB and ABC interactions have no or less effect to the results.

Discussion

Biologically children have shorter height of disc and small annulus percentage compared to adult, which suit the factors selected for this study. The closest combinations with published data were shorter height (6mm), smaller AF volume (40%) and 1.31 MPa silicone rubber. (Refer Table 2). Since the published data were varied in age, no direct comparison can be made. However, the modulus of this study was within modulus of young adult while stiffness lowers than the range. Although all factors influenced the results the largest main effect was disc height. The key element in this study is to design flexible children AID. Future works will be focused on the range of motion of complete synthetic spine model with selected AID in spine simulator.

Description	Compression modulus (MPa)	Compression stiffness (N/mm)
Human [Stemper et al, 2010]		
28± 8 yrs old	19.5 ± 4.1	3300 ± 642
AID [Hawkins et al, 1995]		
Homogenous A70	15.78 ± 0.9	1697 ± 105
57 % AF	20.81 ± 2.61	1923 ± 226
This study	15.63 ± 0.4	2016 ± 59

Table 2: Comparison table.

References

Clark *et al*, Can J Surg, 44:337–45, 2001.
Hawkins *et al*, J Appl Biomater 6:117-123, 1995.
Stemper *et al*, J Craniovert Jun Spine, 1:4, 2010.