

ARE HEMISPHERIC ACETABULAR CUP DESIGNS PREFERABLE TO PERIPHERALLY ENHANCED DESIGNS IN UNCEMENTED HIP ARTHROPLASTY?

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INTRODUCTION

The primary stability of uncemented press-fit acetabular cups is critical for osseointegration and implant longevity. While patient-specific and surgical factors influence the performance of uncemented components, cup design is also fundamental in achieving an initial (primary) stability between the acetabular component and the reamed cavity, thereby minimising micromotion and promoting long term bone ingrowth [1]. Different cup designs are commercially available but the choice of geometry to optimise this press-fit is controversial. The aim of this research was to compare the primary stability of commercially available hemispheric and peripherally enhanced cup designs *in-vitro*.

METHODS

Two commercially available acetabular cup designs were tested. The hydroxyapatite-coated titanium cups (diameter 52mm) were produced by the same manufacturer (Stryker UK Ltd., Newbury, UK) and differed only in geometry – one being purely hemispheric and the other being peripherally enhanced (peripheral self locking - PSL).

Cups were seated in reamed polyethylene bone analogue of low (0.22gcm^{-3}) and high (0.45gcm^{-3}) density. The densities of the mechanically consistent polyethylene analogue mimicked two qualities of bone (softer and harder) while obviating inherent variations in cadaveric bone [2]. The cavities were made using the reamers supplied by the cup manufacturer. In the low density analogue, a conventional 2mm diametral press-fit was employed. However, neither design could be adequately seated in the high density analogue using this 2mm interference fit. Consequently, a 1mm diametral press-fit was employed, as recommended by the manufacturer.

Once seated, the primary stability of each design was investigated by recording the peak failure load during uniaxial pull-out and tangential lever-out tests. For each failure mode, ten repetitions were performed for the hemispheric and PSL cup designs in both high and low density bone analogue, resulting in a total of 80 tests. Potential between-cup differences in peak seating force,

pull-out force and lever-out moment were evaluated for each test using independent samples t-tests. For all tests, statistical significance was taken at $p < 0.05$.

RESULTS AND DISCUSSION

There was no statistically significant difference in seating force or pull-out and lever-out stability between the PSL and hemispheric designs in the low density analogue (Table 1).

Even with only a 1mm press-fit, average seating forces for both cups in the high density analogue were greater than those in low density analogue. In the high density analogue the hemispheric design required a significantly lower seating force than the PSL ($p = 0.016$). Once seated, however, there was no statistically significant difference in pull-out and lever-out stability between the cup designs in high density analogue (Table 1).

CONCLUSIONS

The high density analogue represents the harder bone of younger patients where uncemented cups are mainly used. In this analogue, the hemispheric design achieved a similar primary stability to the peripherally enhanced geometry but required a 20% lower seating force giving a superior stability to seating force ratio. The effect was not evident in low density analogue.

These results emphasises the importance of bone density in selecting uncemented acetabular designs. In the clinical setting this is a crucial finding because high seating forces during cup insertion may result in bony fracture or implant malposition. On this basis the hemispheric cup geometry would seem preferable in younger patients.

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Table 1: Seating force and pull-out and lever-out stability of cups in low (0.22gcm^{-3}) and high (0.45gcm^{-3}) density analogue.

	n	Low Density analogue (2mm press-fit)		High Density analogue (1mm press-fit)	
		PSL	hemispheric	PSL	hemispheric
Seating Force (N)	20	4649 ± 1115	4078 ± 1055	7858 ± 2383 *	6264 ± 1535 *
Pull-out Force (N)	10	707 ± 50	668 ± 72	1424 ± 338	1553 ± 429
Lever-out Moment (Nm)	10	16.2 ± 2.0	14.4 ± 2.5	39.8 ± 7.0	37.2 ± 5.4

* indicates a statistically significant difference between cups for the given analogue density.