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Does the Ingrowth Surface Make a Difference? A Retrieval Study of 423 Cementless Acetabular Components

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ABSTRACT

The effect of factors such as design, alloy and coating type on bony or fibrous tissue ingrowth was evaluated in a study of 423 retrieved cementless acetabular shells representing 16 shell designs. Small-beaded (250 µm) porous coatings, either with or without hydroxyapatite (HA) coatings, proved to be the superior porous surface for bone ingrowth. Small-beaded shells that were Duofix coated had predominantly fibrous tissue ingrowth. In addition to bead size, alloy type and surface type have significant effect on bone ingrowth. In contrast, there is no significant association between bone ingrowth and time in situ, with most bone ingrowth occurring early. Although roughened, press-fit shells have acceptable clinical and Registry data, they showed some of the lowest ingrowth/ongrowth scores of all the shells tested.

Cementless arthroplasty components, such as the articular shell, rely on bone ingrowth or bone attachment (ongrowth) to the porous surface to provide fixation and stability. The porous coating can be sintered beads (Fig. 1A, B, D), wire or fibre mesh (Fig. 1C), trabecular metal (Fig. 1E) and a roughened surface for press-fit devices (Fig. 1F). These coatings incorporate 3-dimensional porous networks of varying porosity. The porosity of wire mesh is approximately 30%–40%, sintered beads from 30% to 50% and trabecular metal from 70% to 80% [1]. The surfaces can also be plasma sprayed with hydroxyapatite and/or metal powder. The effectiveness of different surfaces and surface treatments to promote osseointegration of the acetabular component is poorly documented and most acetabular shell retrieval studies deal specifically with location and histology of the ingrowth [2–5]. Plain radiographs are often used as a surrogate marker of bone ingrowth but are limited in resolution because they attempt to capture a three-dimensional process in two-dimensions. Whilst implant registries are useful in comparing survivorship for a range of acetabular–femoral component combinations, they mostly do not record the revision rates of specific acetabular shells, making it difficult to compare different porous surfaces. Joint registries also use revision as a criterion of failure and can overestimate true success rates. For example, patients with loose implants that have not been revised are not taken into account [6].

Our implant retrieval laboratory has in excess of 400 cementless acetabular shells in its collection, representing a variety of designs, porous surfaces and implantation times. Features of the shell that may influence osseointegration include bead size, pore size, coating type and/or surface treatment, alloy type and various design features to minimise micromotion such as screws, pegs or fins [1,4,7,8]. The type of bearing couple, the liner locking design and the processing and sterilisation of the polyethylene liner may also affect failure of fixation due to wear-particle induced osteolysis [8–11]. Clinical factors such as patient activity, bone quality, implant positioning and initial implant stability are also significant. To facilitate bone ingrowth, micromotion should be less than 150 µm [8].

Although retrieved acetabular components represent a failed cohort of implants, it is nonetheless possible to evaluate how various component design features and clinical factors may affect osseointegration. The principal aim of this study was to examine the average bone ingrowth of 16 different acetabular cup designs and attempt to answer questions relating to the optimum porous surface, the optimum bead size and the extent factors such as design, bead size, alloy and coating type, affect bone or fibrous tissue ingrowth.

Materials and Methods

423 retrieved, cementless acetabular components representing 16 different shell designs were examined for fibrous tissue and bone ingrowth (Fig. 2). Inclusions were based on two criteria; acetabular components required to be in situ for 3 months or more and shell types represented by a minimum of 5 samples. Three months was chosen because most bone ingrowth occurs early, within the first 6–12 weeks of implantation [3,12]. The average time in situ for the 16 shell types ranged from 2 years to 18 years. All retrieved shells were EtO sterilised

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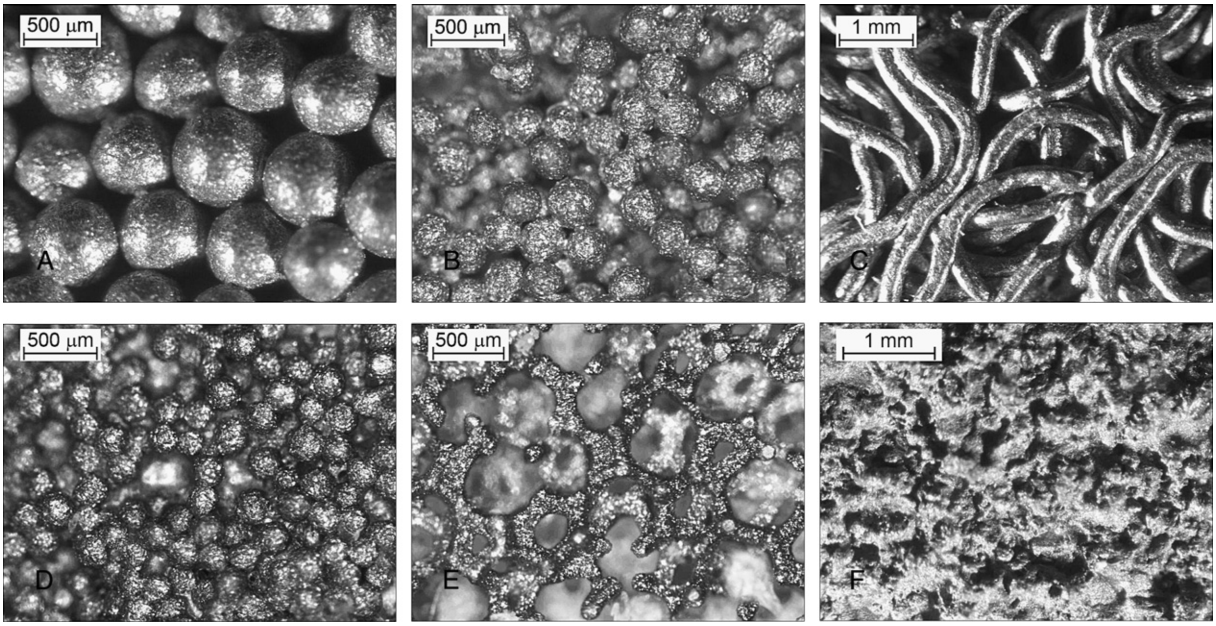

Fig. 1. Shell ingrowth surfaces. (A) Large beads: Reflection (580 µm). (B) Small beads: Reflection small bead (250 µm). (C) Wire mesh: HG II. (D) Duofix (plasma sprayed, HA coating): Pinnacle. (E) Trabecular metal: TM Modular. (F) Roughened surface: Trident.

after removal, bagged and stored dry. Bone ingrowth was measured independently by two trained observers using both visual and stereomicroscopic techniques. The following methods were employed: The shell was placed flat on a surface and four quadrants were projected axially (Fig. 3A). The number of quadrants containing bone (0–4) was recorded for each device. The location of the quadrants is not orientation specific. In addition, the porous surface of each cup was divided into two distinct regions, the pole half and the rim half (Fig. 3B). With the four quadrants still projected, the percentage bone and tissue ingrowth was calculated for each quadrant in the rim half as well as the pole half. All values were then averaged for both rim and pole regions.

The percentage bone and fibrous tissue ingrowth or ongrowth was then determined for each region. It should be noted that bone or tissue ongrowth is usually limited to the press-fit shells with roughened surfaces. For this study, no differentiation was made between bone/tissue ingrowth and ongrowth. As the orientation of the shell is unknown in the majority of cases, the number of quadrants containing bone is an indication of the extent of ingrowth. In contrast, bone/tissue ingrowth on either the pole or rim is specific to a defined region of the shell similar to that described by Delee and Charnley [13].

It should be noted that fibrous tissue values are very much approximations as tissue coverage is difficult to differentiate when not observed fresh. For this reason a consensus method was adopted between the two observers when recording fibrous tissue ingrowth for each shell. In addition, when it was obvious that bone or fibrous tissue had been removed during the retrieval process, an estimation of bone and/or fibrous tissue ingrowth was determined. This was based on the proportion of the area of ingrowth removed and the average bone or fibrous tissue ingrowth still attached to the sample. This was only necessary in a small number of shells and generally involved small regions. The type of porous surface, the type of surface treatment, whether or not screws were used and the average bead size for each beaded component were recorded for all shell types (Table 1). Relevant clinical data such as time in situ and reasons for removal were also recorded (Table 2). The Duofix coated shells (Pinnacle and ASR) differ from a similar size beaded shell (Duraloc) from the same manufacturer. Duofix is a plasma sprayed hydroxyapatite coating over a sintered bead surface. Unique to Duofix coatings, alumina ceramic particles used for roughening the beads prior to hydroxyapatite coating, were not sufficiently removed by cleaning and have been implicated in increased wear and metallosis with the LCS knee [14,15]. This may lead to adverse tissue

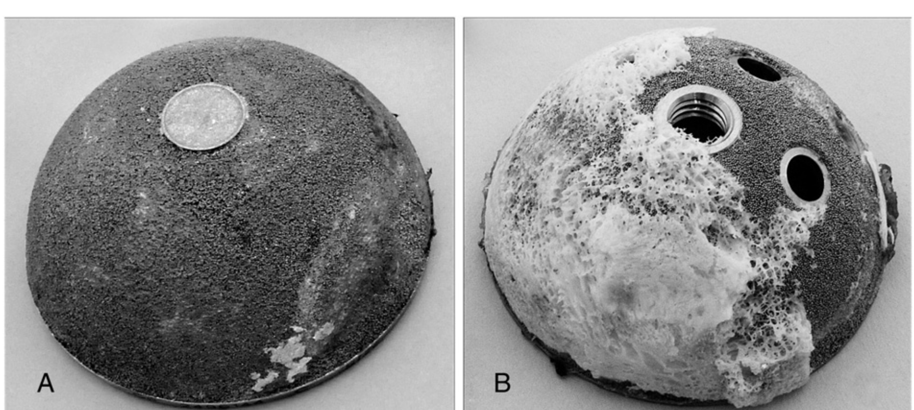

Fig. 2. Bone ingrowth in two small-beaded shell types. (A) ASR (<5% bone ingrowth). (B) Reflection small bead (50% bone ingrowth).