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Introduction:

Clinical results of pyrolytic carbon (PyC) arthroplasty for small joints of the hand are mixed. To shed further light on this, three related topographical studies were undertaken: a study that evaluated the surfaces of 8 unused proximal interphalangeal (PIP) components (4 pairs) of different sizes [1-4]; an ex vivo study that evaluated 10 retrieved components [5]; and an in vitro study that evaluated 4 PIP components (2 pairs) to 5,000,000 cycles [6-8].

Methods:

In all studies, topographical plots of the surfaces were taken using an optical interferometer with a sensitivity of 1nm. 3D average roughness (S_a) was calculated from each plot obtained. In addition to this, the radii of the unused prostheses were determined using a coordinate-measuring machine. This was for two pairs of each nominal size available (size 10, size 20, size 30 and size 40). For the ex vivo study, 10 components were retrieved from patient fingers: four distal and two proximal components from PIP joints; one distal and one proximal from a metacarpophalangeal joint; and two components from carpometacarpal joints. Time in vivo ranged from 3 weeks to 3 years. For the in vitro study, a finger simulator was used to test two sizes (one size 30, one size 40) of PIP prosthesis to 5,000,000 test cycles. This simulator has been used to evaluate other two-piece prosthesis designs [9-11]. R.O.M was limited to 90°-0° flexion-extension, with dynamic forces of 10-15N. At intervals of 3,000 cycles, a static load of 100N was applied for 45 seconds. Dilute bovine serum at 37°C was used as the lubricant. An additional two control prostheses (same sizes as test prostheses) were used to account for any lubricant uptake. In addition to the topographical plots, gravimetric wear measurements were taken at regular intervals until the test was ended after 5,000,000 cycles.

Results:

In ascending order of nominal size, the unused prostheses yielded radii of 2.5; 3.3; 4.2; and 4.7mm for the proximal condyles, along with radii of 4.0; 5.1; 5.6; and 6.3mm for distal plateaux. The mean, non-stratified S_a value was 20nm (95% CI 30 to 41nm). Furthermore, S_a correlated negatively with radius (p=0.001). The ex vivo study revealed the largest component (carpometacarpal) to yield the lowest S_a (12nm). Conversely, the smallest components evaluated (distal interphalangeal) yielded the highest S_a values: with a mean of 37nm ranging from 17 to 66nm. From the in vitro study all four of the size 40 components and three of the size 30 components showed a negligible change in S_a. The remaining size 30 component reached more than double its original S_a at 5,000,000 cycles (from 37 to 75nm).

Discussion:

The lack of marring on the surfaces of the 10 retrieved components suggests that they were unworn and hence that the reason for removal was not wear related. Low wear and minimal changes in S_a for most components was confirmed by the 5,000,000 in vitro test cycles. When studied in detail it was found that unused components with the smallest radii exhibited the highest S_a values. Smaller components may be more difficult to polish.

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