Naylor A, Bone MC, Unsworth A, Talwalkar S, Trail IA, Joyce TJ.

Evaluating the wear and surface roughness of pyrocarbon finger prostheses tested in vitro.

***In: 10th Anniversary Bath Biomechanics Symposium: Current Issues and Future Opportunities in Orthopaedic Research*. 2014, University of Bath: The Centre for Innovative Manufacturing in Medical Devices.**

EVALUATING THE WEAR AND SURFACE ROUGHNESS OF PYROCARBON FINGER PROSTHESES TESTED IN VITRO

*Naylor, A., *Bone, M.C., **Unsworth, A., ***Talwalkar, S., ***Trail, I.A., *Joyce, T.J.
*Newcastle University, Newcastle upon Tyne, UK
**University of Durham, Durham, UK
***Wrightington Hospital, Wigan, Lancashire, UK

Introduction

The clinical trial record of the pyrocarbon proximal interphalangeal (finger) prosthesis is mixed (Reissner et al., 2014; Tägil et al., 2014). Further to this, evidence of only two series of in vitro tests has been found (Ascension Orthopadics., 1999; Strzepa and Klawitter., 2005) both of which were commissioned by Ascension Orthopaedics, the manufacturer of the prosthesis. A further programme of impartial in vitro tests was conducted by the authors of this study using finger joint simulators, testing prostheses to five million cycles of flexion and extension.

Materials and Methods

In two dedicated finger simulators, two different size pyrocarbon test prostheses were cycled through flexion-extension (90°-0°). These prostheses were labelled size 30 (nominal weight of 1.2 g) and size 40 (nominal weight of 1.6 g). Pneumatic cylinders were used for the flexion extension mechanism with dynamic forces of 10-15 N. Every 3,000 cycles, flexion-extension ceased and a static load of 100 N was applied for 45 seconds to simulate a static 'pinch' load. Bovine serum at 37ºC was used as the lubricant with control prostheses immersed to account for lubricant uptake. At intervals of one million cycles, wear and roughness average (Ra) measurements were taken using gravimetric and non-contacting profilometry techniques respectively.

Results

After five million cycles of flexion-extension a negligible change in weight was observed (to a sensitivity of 0.1 mg), hence it can be stated that no wear occurred. The majority of Ra values taken from the components remained below the recommended limit of 50 nm (British Standards., 2011). One exception to this was the size 30 proximal component: which increased from 37 nm prior to testing; to 75 nm post five million cycles.

Discussion

The increased roughness was attributed to a single condyle on the size 30 prosthesis: which had an initial Ra value of 46 nm prior to testing; rising to 130 nm post five million cycles. Micrographs of this condyle indicated unidirectional marks consistent with an abrasive wear mode. The lack of gravimetric wear documented in this study matches the findings of two previous in vitro studies (Ascension Orthopadics., 1999; Strzepa and Klawitter., 2005). Neither of these studies however investigated surface roughness, therefore the data reported here adds to earlier work.

Conclusion

The in vitro results are mixed, mirroring the clinical trials (Reissner et al., 2014; Tägil et al., 2014). Overall the measured gravimetric wear was low and the majority of the pyrocarbon components remained below the roughness limit post five million cycles. However, one condyle of one test component significantly increased in roughness above the 50 nm recommended limit.

References

Ascension Orthopedics. *Test Report*: *TR-0008-01 - PyroCarbon Wear.* 1999.

British Standards. *BS ISO 7206-2 Implants for surgery: Partial and total hip joint prostheses Articulating surfaces made of metallic, ceramic and plastics materials*. 2011.

Reissner L, Schindele S, Hensler S, Marks M, Herren DB. *Ten year follow-up of pyrocarbon implants for proximal interphalangeal joint replacement*. Journal of Hand Surgery (European Volume). 2014, 39: 582-6.

Strzepa P, Klawitter JJ. *Ascension pyrocarbon hemisphere wear testing against bone*. 51st annual meeting of the orthopedic research society. Washington, D.C., 2005.

Tägil M, Geijer M, Abramo A, Kopylov P. *Ten years' experience with a pyrocarbon prosthesis replacing the proximal interphalangeal joint. A prospective clinical and radiographic follow-up.* Journal of Hand Surgery (European Volume). 2014, 39: 587-95.

Acknowledgement

Ascension Orthopaedics supplied test components free of charge.

Affiliations

*School of Mechanical and Systems Engineering, Newcastle University, NE1 7RU, UK. andrew.naylor@ncl.ac.uk
**School of Engineering and Computing Sciences, Durham University, DH1 3LE, UK.
***Upper limb unit, Wrighington hospital, Wigan, Lancashire, UK, WN6 9EP.