



Raelene M. Cowie¹, Adam Briscoe², John Fisher¹, Louise M. Jennings¹

¹Institute of Medical and Biological Engineering, School of Mechanical Engineering University of Leeds, UK ²Invio Bio Material Solutions, Thornton Cleveleys, UK
Contact email: r.cowie@leeds.ac.uk

Background

There has been an increased interest in the use of PEEK-OPTIMA® Natural (PEEK) as an arthroplasty bearing material due to its potentially low wear rates, favourable mechanical properties, and the biointegrity of its wear debris [1].

In this study, the potential to use PEEK as a substitute for the hard bearing material in joint replacements was investigated, with results being compared to cobalt chrome. The influence of lubricant temperature on the wear of UHMWPE pins articulating against both PEEK and cobalt chrome plates in a pin on plate rig was investigated. Testing was carried out at room temperature, as per standard practice at Leeds and at body temperature.

Materials and Methods

Materials: GUR 1020 UHMWPE pins (8mm flat contact face) were tested against either highly polished cobalt chrome (initial $R_a < 0.1\mu\text{m}$) or injection moulded PEEK plates (initial $R_a < 0.06\mu\text{m}$) provided by Invivo Ltd, UK.

Methods: Leeds 6 station multi-axial pin on plate reciprocating rig (Figure 1). Test conditions used :

- 20mm stroke length
- Frequency 1Hz
- Rotation $\pm 20^\circ$
- 160N load
- Contact pressure 3.18MPa
- Room temperature or 36°C
- 25% bovine serum was used for lubrication
- 1 million cycles (MC)



Figure 1: Leeds 6 station pin on plate rig (without the heater system)

Wear of the pins was assessed by gravimetric analysis every 0.3 MC and the bulk serum temperature was measured daily with a thermocouple.

Results

Figure 2:

- At room temperature, the wear of UHMWPE articulating against PEEK was significantly (ANOVA $p=0.07$) higher than against cobalt chrome.
- At increased temperature, the wear of UHMWPE was similar against both PEEK and cobalt chrome ($p=0.39$)
- At increased temperature, the wear of UHMWPE against PEEK was significantly ($p=0.017$) lower than at room temperature

Table 1:

- At room temperature, the mean lubricant temperature was $\sim 1^\circ\text{C}$ higher in UHMWPE-PEEK
- At increased temperature, the lubricant temperature was similar for both couples

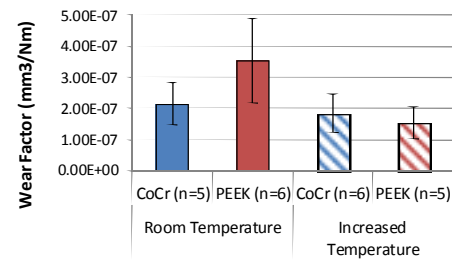


Figure 2: Wear Factor (mm^3/Nm) of GUR1020 UHMWPE pins articulating against PEEK and cobalt chrome plates at room temperature and an elevated temperature.

Table 1: Temperature of the lubricant ($^\circ\text{C}$) during testing.

		PE-CoCr	PE-PEEK
Test conditions	Room Temperature	26.7	27.5
	Increased Temperature	37.2	37

Discussion

- The higher wear volume of UHMWPE-PEEK bearing couple may in part have been due to the higher initial surface roughness of the PEEK plates compared to CoCr.
- Temperature did not influence the wear of UHMWPE-CoCr.
- The higher friction UHMWPE-PEEK bearing couple [2] may have contributed to the elevated lubricant temperature due to frictional heating [3] and higher wear.
- At elevated temperatures, protein from the serum precipitated onto the articulating surfaces may have produced a protective layer resulting in an artificially low rate of wear against PEEK [4] [5].

Conclusion

The study shows the importance of the environmental conditions during biotribological testing especially in potentially high friction bearing couples such as UHMWPE- PEEK-OPTIMA® Natural.

References

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Acknowledgements

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