A comparative study of osteoblast response to PEEK or titanium commonly used in dental implants.

G. Gronowicz[1], K.Sagomonyants[1], J. Devine[2], M. Jarman-Smith[2]
[1]Dept. of Orthopedic Surgery, University of Connecticut Health Center, Farmington, CT 06030-1110 USA.
[2]Invibio Ltd., Thornton Cleveleys, UK.

AIMS OF THIS STUDY

An *in-vitro* study to:

- directly compare the cytocompatibility of human primary osteoblasts with the best performing** commercially pure titanium (cpTi Grade 1) and two implantable PEEK-based biomaterials
  - Unfilled PEEK
  - Carbon fiber-reinforced PEEK
- determine whether implantable grade PEEK could be a suitable future candidate for dental implantation and progress to subsequent relevant mechanical tests.

BACKGROUND

- **Polyetheretherketone (PEEK**) is a high performance thermoplastic used as an alternative to metals or ceramics.
- PEEK is often used in spinal fusion cages and orthopedic applications.
- PEEK confers many beneficial properties for implants
  - X-ray and MRI compatibility
  - mass production through injection molding and machining
  - chair-side modification for clinician
  - high chemical, heat and hydrolysis resistance
  - versatility (it can be chemically modified, coated or compounded with other materials)
- There are few studies directly comparing PEEK to titanium in a human primary osteoblast model.
- The best performing commercially pure titanium** was used as a control in this study.

**Ahmad *et al.*(1999). "Differential response of human osteoblast-like cells to commercially pure (cp) titanium grades 1 and 4". *Journal of Biomedical Materials Research*. 46,1, 121-131.

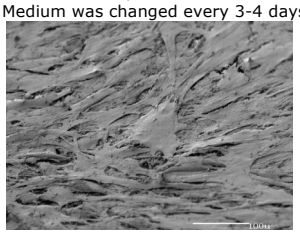
For additional information:

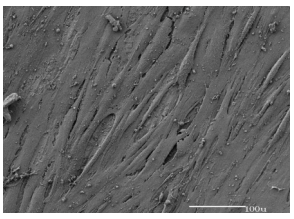
**Invibio Ltd.,
Hillhouse International,
Thornton Cleveleys.
Lancashire. FY5 4QD.
United Kingdom.**

+44 1253 898010

METHODS

- Implantable grade PEEK was prepared as disks 10 mm in diameter.
- Unfilled or carbon fiber-reinforced (CFR) PEEK-OPTIMA® was presented to the cells as either injection molded or machined.
- Commercially pure Grade 1 titanium disks were prepared from sheet stock (A.D.MacKay, Inc., Red Hook, New York).
- The titanium surface was presented as industrially polished (polished cpTi) or prepared to a 600 grit finish with silicon carbide metallurgical paper (unpolished cpTi) (Ra=0.5).
- Human primary osteoblasts (HOBs) derived from bone discarded from middle aged male and female patients were allowed to outgrow from the bone chips in DMEM/F-12 medium with 15% fetal bovine serum (FBS) and antibiotics.
- After 2-3 weeks of growth, HOBs were replated in the same medium onto sample disks at a density of 10,000 cells/cm^2.
- For mineralization studies, after one week in culture, the medium was changed to alpha-MEM with 15% FBS, and antibiotics with 50 μg/ml ascorbic acid added daily for a further 2 weeks. Medium was changed every 3-4 days.





Upper: Machined CFR-PEEK with 3 day HOB culture. Mag x 250.
Lower: Unpolished cpTi with 3 day HOB culture. Mag x 250.

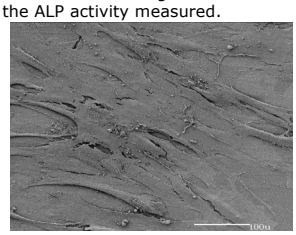
- The HOB response was observed for:
  - initial adhesion at 4 hours
  - proliferation at 48 hours by [3H]-thymidine incorporation
  - alkaline phosphatase activity at 72 hours
  - Mineralization (calcium content) was measured biochemically after 2 weeks of culture in alpha-MEM.
- Experiments were repeated 2-3 times for each assay.

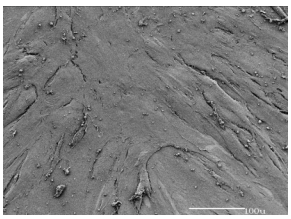
RESULTS / DISCUSSION

At 4 hours
- All biomaterials showed HOB adhesion.
- The cpTi demonstrated no significant difference between surface type.
- Injection molded PEEK surfaces had no significant difference in adhesion when compared to cpTi. However, machined PEEK surface demonstrated significantly less adhesion (p=0.01).

At 48 hours
- Proliferation was significantly greater (p=0.01) on the injection molded, unfilled PEEK compared to other test materials.
- The surface on titanium (polished or unpolished) or CFR-PEEK (injection molded or machined) did not have a significant effect on proliferation.

At 72 hours
- ALP activity (μM/min/mg protein) was greatest on injection molded unfilled PEEK and polished titanium, with no significant difference between them.
- The surface finish within each material tested had some significant effect on the ALP activity measured.





Upper: Injection molded PEEK with 3 day HOB culture. x 250.
Lower: Polished cpTi with 3 day HOB culture. Mag x 250.

At 3 weeks
- Mineralization (calcium content) was greatest on machined unfilled PEEK and significantly higher than polished cpTi (p=0.01) or machined CFR-PEEK (p=0.03).
- No significant differences were found between the best performing cpTi (unpolished) or the injection molded CFR-PEEK or unfilled PEEK (Figure 1).

CONCLUSIONS

- These results demonstrate that the *in-vitro* performance of two PEEK-based biomaterials (unfilled or carbon fiber-reinforced PEEK-OPTIMA®) presented to the cells as either injection molded or machined, were comparable to that of Grade 1 cpTi commonly used for endosteal dental implants.
- All *in-vitro* parameters (adhesion, proliferation, alkaline phosphatase activity and mineralization) appear to be influenced by the surface finish of the material as generated using common manufacturing techniques such as polishing, injection molding or machining. However, human osteoblasts did adhere to all test materials.
- The presence of mineralization suggests that PEEK may lend itself to the osseointegration of dental implants and that further work should follow to investigate fulfilling the mechanical requirements of such an implant system.

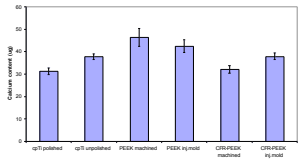
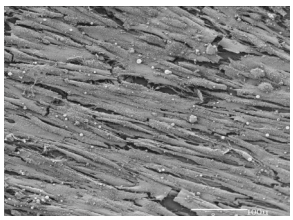


Figure 1: Calcium content measured from HOB cultures on cpTi, PEEK or CFR-PEEK variants after 3 weeks.



Above: Machined PEEK with 3 week HOB cultures. Mag x250.
Below: Machined CFR-PEEK with 3 week HOB culture. x1000