The long-term mechanical integrity of non-reinforced PEEK-OPTIMA polymer for demanding spinal applications : experimental and finite-element analysis

Polyetheretherketone (PEEK) is a novel polymer with potential advantages for its use in demanding orthopaedic applications (e.g. intervertebral cages). However, the influence of a physiological environment on the mechanical stability of PEEK has not been reported.
Furthermore, the suitability of the polymer for use in highly stressed spinal implants such as intervertebral cages has not been investigated. Therefore, a combined experimental and analytical study was performed to address these openques-tions. A quasi-static mechanical compression test was performed to compare the initial mechanical properties of
PEEK-OPTIMA polymer in a dry, room-temperature and in an aqueous, 37C environment (n=10 per group).
The creep behaviour of cylindrical PEEK polymer specimens (n=6) was measured in a simulated physiological environ-ment at an applied stress level of 10 MPa for a loading duration of 2000 hours (12 weeks). To compare the biomechanical performance of different intervertebral cage types made from PEEK and titanium under complex loading conditions, a three-dimensional finite element model of a functional spinal unit was created.
The elastic modulus of PEEK polymer specimens in a physiological environment was 1.8% lower than that of specimens tested at dry, room temperature conditions ($P<0.001$).
The results from the creep test showed an average creep strain of less than 0.1% after 2000 hours of loading.
The finite element analysis demonstrated high strain and stress concentrations at the bone/implant interface, emphasizing the importance of cage geometry for load distribution. The stress and strain maxima in the implants were well below the material strength limits of PEEK.
In summary, the experimental results verified the mechanical stability of the PEEK-OPTIMA polymer in a simulated physiological environment, and over extended loading periods.
Finite element analysis supported the use of PEEK-OPTIMA for loadbearing intervertebral implants.

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