Comparative Analysis of PEEK, PLDLLA, and 3D-Printed PLA Screws

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INTRODUCTION:

The choice of material for orthopedic screws significantly impacts osteointegration and clinical outcomes. This study compares the performance of Polyetheretherketone, Poly, and 3D-printed Polylactic Acid screws in terms of bone ingrowth and biocompatibility.

PEEK is known for its biocompatibility and mechanical properties, while PLDLLA and PLA offer bioresorbable options that may promote bone regeneration. However, the temporal patterns of osteointegration for these materials can vary. Prior research indicates that the immune responses and inflammatory reactions after implantation would interfere with the osteogenic process when using PEEK. Eventually, the proliferation of fibrous tissue and the formation of fibrous capsules would result in a loose connection between PEEK and bone, leading to implantation failure.

METHODS:

Micro-CT analysis and histological evaluation were conducted to assess bone-to-implant contact and tissue response at 4-, 8-, 12-, and 16-weeks post-implantation.

RESULTS:

Micro-CT analysis revealed distinct temporal patterns of osteointegration for each screw type. At 4 weeks, PLA screws exhibited a significantly higher mean BIC (75%) compared to PEEK (0%) and PLDLLA (68.8%). By 8 weeks, BIC values were 78% for PLA, 74% for PEEK, and 73.6% for PLDLLA. However, by 16 weeks, all three materials demonstrated complete osteointegration, achieving 100% BIC. Histological analysis at 4 weeks revealed that PLA screws, while showing early BIC, were located within articular cartilage and exhibited signs of pseudoarthrosis and synovial metaplasia. PEEK screws showed fibrointegration, moderate periprosthetic fibrosis and inflammation, and high neovascularization. PLDLLA screws also showed fibrointegration, mild peri-prosthetic fibrosis, high neovascularization, and focal osteoid formation. At 8 weeks, PEEK screws continued to exhibit fibrointegration, marked peri-prosthetic fibrosis, abundant neovascularization, and limited bone formation. PLDLLA screws showed mature bone formation with abundant neovascularization, moderate inflammation, and efficient bone mineralization. At 12 and 16 weeks, all three materials exhibited similar integration processes, with bone coating around the screws, demonstrating osteointegration, scarce neovascularization, and periprosthetic fibrosis.

DISCUSSION AND CONCLUSION:

While all three materials achieved complete osteointegration by 16 weeks, they exhibited different early-stage behaviors. PLA showed early BIC but with signs of cartilage integration, PEEK demonstrated fibrointegration, and PLDLLA showed mature bone formation. By 12-16 weeks, the integration process for all three materials converged towards a similar pattern of bone coating, osteointegration, scarce neovascularization and periprosthetic fibrosis. These findings suggest that the choice of material should be tailored to the specific clinical needs and desired timeline for osteointegration.