DECEMBER 11-12,2025
۲۱ و ۲۰ آذر ماه ۱۴۰۴
دومین کنگره پلاسما پزشکی ایران
The 2 nd Congress on Plasma Medicine
دبیرخانه دائمی کنگره پلاسما پزشکی ایران
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Braided Nitinol Lumbar Implants with Tailored Porosity and Roughness: A Versatile Platform for Future Plasma Surface Enhancement

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Citation:
Tehranian A, Parsafar M, Ardalani R. Braided Nitinol Lumbar Implants with Tailored Porosity and Roughness: A Versatile Platform for Future Plasma Surface Enhancement. *Iran Biomed J*. Supplementary (2-2026): 42.

ABSTRACT

Introduction: The increasing prevalence of orthopedic disorders, particularly in the lumbar region, necessitates advanced implant technologies that can provide both bone-like mechanical properties and excellent biocompatibility. Nitinol, due to its super-elasticity, elastic modulus similar to that of bone, and proven biocompatibility, has emerged as a preferred material for spinal implants. This study aimed to develop a Nitinol lumbar vertebral implant through an innovative two-step manufacturing process that combines sintering and braiding techniques. This approach seeks to achieve optimal mechanical performance while enhancing biological properties, overcoming the limitations of previous methods that prioritized only one aspect.

Materials and Methods: Equiatomic NiTi powder with 50% porosity (using urea as space holder) was compacted at 150 MPa and sintered in an argon atmosphere at 1050°C for 2 hours. The resulting porous rod (7 mm height × 5 mm diameter) was then covered with a braided Nitinol wire structure (0.25 mm wire diameter) following a custom braiding pattern to create the rod. Samples were characterized by scanning electron microscopy (to measure pore size), atomic force microscopy (for surface roughness), electrochemical impedance spectroscopy (for corrosion resistance), and the MTT assay (to evaluate cytotoxicity and cell viability over 21 days).

Results: The braided implants exhibited an average pore size of 310 µm and a surface roughness of 971.1 nm—both ideal for osteoblast attachment and proliferation. Corrosion resistance reached 7366 Ω.cm². Cell viability remained at 95.1% after 21 days, confirming excellent biocompatibility and non-toxicity.

Conclusion: The novel sintering–braiding technique successfully produced Nitinol lumbar vertebral implants with optimized mechanical and biological performance, offering significant potential for improving clinical outcomes in vertebral fusion surgeries.

Keywords: Biocompatibility, Corrosion resistance, Braiding technique, Nitinol, Vertebral implant

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