

# Biomaterial Structure-Property Relationships Critical to the Performance of Metallic Endosteal Implants

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## **Abstract**

Restoration of missing or diseased teeth is often accomplished with endosteal dental implants. Titanium, the material predominantly used for commercial endosteal devices, possesses bulk properties known to be compatible with the environment of the oral cavity. However, despite the high clinical success rates of root-form implants, peri-implant loosening remains the leading cause of dental implant failure. Since anchorage of endosteal implants into the jaw is governed by the implant-bone boundary, a variety of additive and subtractive surface modifications have been used to elicit favorable osteogenic responses. These processing techniques alter microstructural aspects such as surface roughness, porosity, and composition heterogeneity that enhance implant stability. However, though osseointegration will persist as the primary metric for the implementation of new materials for dental fixtures, recent research suggests that the regeneration of soft connective tissue, in addition to bone, at the implant boundary warrants greater consideration. With the emergence of engineered scaffolds and net-shaping technologies, endosteal implant research may overcome the limitations of metal materials through the manufacture of implants with functionally graded structures and properties capable of integrating with dissimilar tooth tissues.

## **1. Background of Endosteal Dental Implants**

### *1.1. History and Clinical Relevance of Endosteal Implants*

Though the practice of filling missing or damaged teeth with shells, stone, and noble metals dates back to ancient civilizations, synthetic tooth replacement remains a pertinent surgical procedure in the modern day [1,2]. Endosteal implants are a subset of dental implant devices characterized by the surgical implantation of a root-like fixture into the jaw bone (Fig. 1a) [2,3]. Three basic geometries exist for endosteal implants, all of which are designed to restore the function of a normally rooted tooth (Fig. 1b). Worldwide, the annual number of endosteal implant procedures exceeds one million, while in the United States alone, dental implant recipients match the combined number of hip and knee arthroplasty patients [2,4].

Endosteal implants are commonly prescribed following tooth loss. Tooth loss can result from various traumatic events or clinical conditions, such as failed root canals and tooth decay [1]. Periodontal disease is leading cause of tooth loss and affects an estimated 93 million people in the United States [5]. Reports from the late 1990s reveal that 30 million people sustain at least one endosseous dental implant [5]. Today, that number is projected to be significantly higher, since nearly 70% of adults lose at least one tooth before the age of 40 [1].