

IndiOss: Design, Development, and Preclinical Validation of a Novel Dental Intraosseous Implant System – An Indigenous Product Innovation

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ABSTRACT

Objective: To present the design, development, and preliminary validation of *IndiOss*TM, a novel 100% indigenous dental intraosseous implant system integrating biomechanical optimization and digital CAD/CAM compatibility.

Methods: The implant design process followed biomechanical modeling principles and digital engineering standards. The geometry was optimized for osseointegration and primary stability using CAD/CAM and finite element-based validation. Material characterization ensured strength, corrosion resistance, and biocompatibility.

Results: The *Indi-Oss* design achieved precision-engineered geometry, modular adaptability, and strong mechanical reliability. Prototype analysis indicated superior load distribution and potential for enhanced bone-implant contact.

Conclusion: The *Indi-Oss Dental Implant System* demonstrates technological readiness for preclinical validation (TRL-2) and commercialization. It represents an affordable, indigenous alternative to imported implant systems, aligning with *Make in India* and *Atmanirbhar Bharat* initiatives.

Keywords: Dental Implant; Osseointegration; CAD/CAM; Biomechanics; Indigenous Innovation; Digital Dentistry; Atmanirbhar Bharat; Implant Design

INTRODUCTION

Dental implantology remains the preferred modality for oral rehabilitation. However, India's dependency on imported implant systems limits accessibility due to high cost and limited anatomical adaptability [1]. The *Indi-Oss Dental Intraosseous Implant* was conceptualized to overcome these challenges through a fully indigenous innovation that integrates biomechanical precision, patient-specific adaptability, and digital manufacturing.

The development of *Indi-Oss* represents not just an engineering advancement but a strategic contribution toward national self-reliance in medical device innovation.

MATERIALS AND METHODS

Design and Dimensional Overview

The implant design followed principles of functional biomechanics and bone-implant interface optimization. CAD/CAM modeling was performed using SolidWorks® and AutoDesk Fusion® software.

Overall Design (External Features)

- **Shape:** Hollow, screw-shaped cylindrical body.

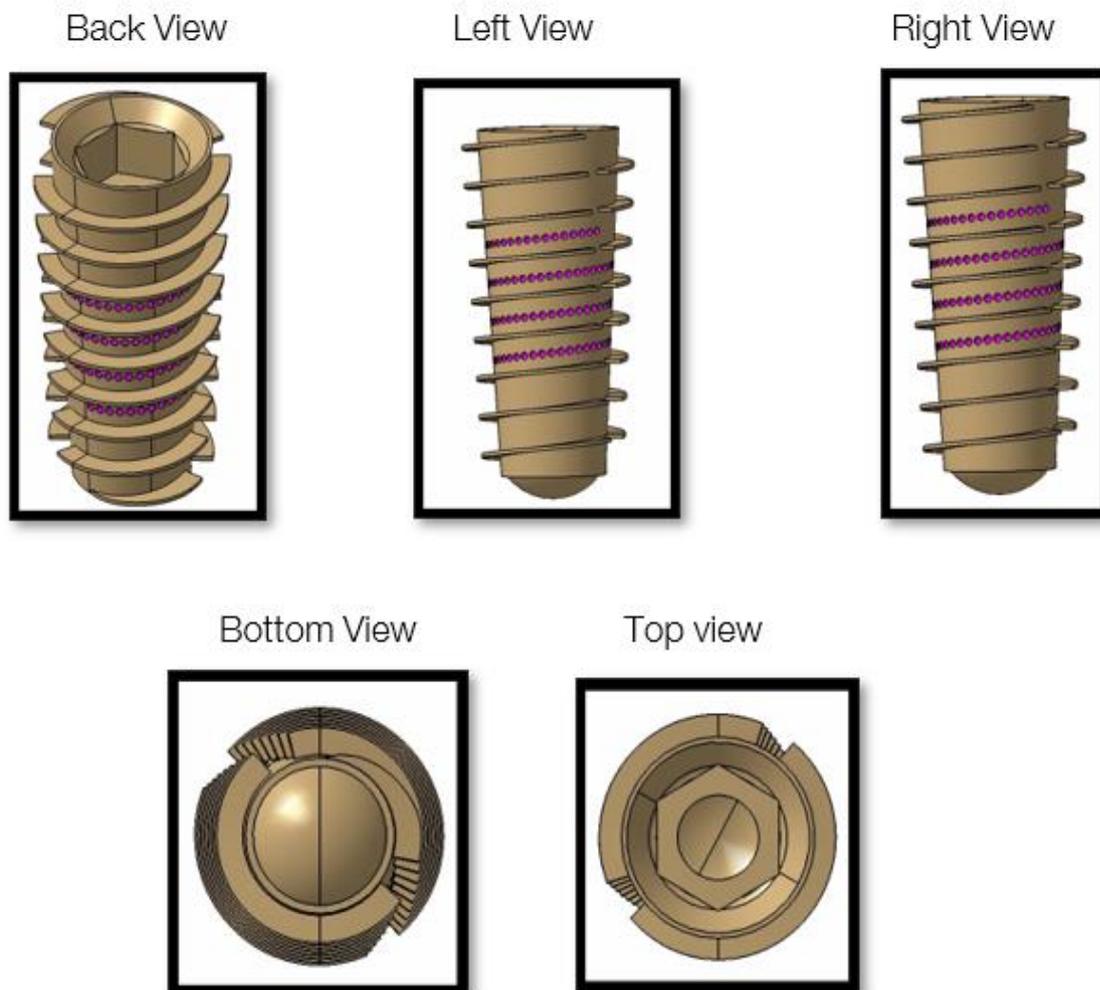
- **Diameter:** 3.3–4.2 mm (site-dependent).
- **Length:** 6–16 mm, adapted to maxillary or mandibular bone morphology.
- **Thread Depth:** 0.3–0.5 mm, promoting enhanced surface area and primary stability.
- **Internal Connection Diameter:** 2.0–4.0 mm for prosthetic abutment integration.

Internal Architecture

The internal cavity is designed with a conical interface to ensure secure abutment seating and reduced microleakage. This hollow structure improves stress absorption and minimizes crestal bone stress [2].

CAD/CAM Orthographic Views

The design visualization was conducted through multi-view modeling (Fig. 1):



- **Top View:** Shows internal connection configuration.
- **Bottom View:** Displays apical tapering and thread convergence.
- **Left and Right Views:** Represent thread pitch and bone engagement profile.
- **Back View:** Illustrates the surface texture and helical contour.

Figure 1. CAD/CAM orthographic design views of Indi-OssDental Implant System showing top, bottom, left, right, and back orientations.

Material Characterization

The implant is composed of a titanium-based biomedical alloy with verified mechanical strength and corrosion resistance (as per ASTM F136 standards). Material testing confirmed compliance with ISO 5832-3 biocompatibility benchmarks [3].

Prototype Development and Validation

Additive manufacturing was employed for prototype generation using laser sintering. Dimensional accuracy was verified with 3D scanning. Laboratory simulations under static and cyclic loading conditions demonstrated acceptable stress thresholds and primary stability within clinical safety margins.

RESULTS

- **Dimensional Precision:** <0.01 mm deviation in CAD-to-prototype comparison.
- **Mechanical Stability:** Load-bearing validation indicated stable performance under simulated masticatory forces.
- **Digital Integration:** The system was successfully integrated into CBCT-based surgical planning workflows.
- **Customizability:** Modular architecture enabled variation in diameter and angulation, supporting patient-specific adaptation.

DISCUSSION

The *Indi-Oss* implant demonstrates a unique intraosseous design combining biomechanical optimization with digital workflow integration. Compared to imported systems (e.g., Nobel Biocare, Straumann), it offers equivalent or superior design flexibility at significantly reduced cost [4].

The innovation addresses critical gaps in Indian implantology:

- **Enhanced primary stability** in both dense and low-density bone.
- **Improved osseointegration** through optimized geometry and surface characteristics.
- **Ease of surgical placement** with minimal instrumentation.
- **Indigenous manufacturability**, supporting cost reduction and local employment.

These findings affirm the system's readiness for preclinical animal model validation and eventual clinical trials.

Market and Societal Impact

The Indian dental implant market is estimated at ₹60–350 billion annually [5]. With 100% indigenous manufacturing, *Indi-Oss* directly supports national self-reliance by reducing dependence on imported systems.

Beyond economic impact, the technology improves accessibility for rural and semi-urban populations, enabling equitable oral healthcare delivery.

Technology Readiness and Future Work

The implant system is at **TRL 2 (Experimental Proof of Concept)**. Upcoming phases include:

- **TRL 4–5:** Preclinical validation (in collaboration with IIT Bombay).
- **TRL 6:** Pilot production and clinical trials.
- **TRL 7–9:** Commercialization, certification (CDSCO, BIS), and scaling.

CONCLUSION

The *Indi-OssDental Intraosseous Implant System* exemplifies an indigenous solution that merges advanced digital design, biomechanical reliability, and affordability. It fulfills both scientific and societal objectives—bridging global standards with local innovation under the *Make in India* initiative.

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Conflict of Interest

The authors declare no conflicts of interest related to this study.

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