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Medical Dental Device: Biogeneric Implant Prototype

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INTRODUCTION

Factors such as genetics, poor dental hygiene, periodontal disease and other health issues may lead to tooth loss in adults. An exfoliated secondary tooth has no biological replacement. While we await breakthroughs in biotechnology, an evolution of prosthetic solutions has been in practice for thousands of years. Dental implants have come a long way and every year different designs are made to solve the problems of the past. Yet even now, we continue to face lengthy treatments and experience implant failures. The new design approaches and advancements in material science benefits both patients and doctors alike.


Figure 1 (Dental Implant)

DESIGN FEATURES

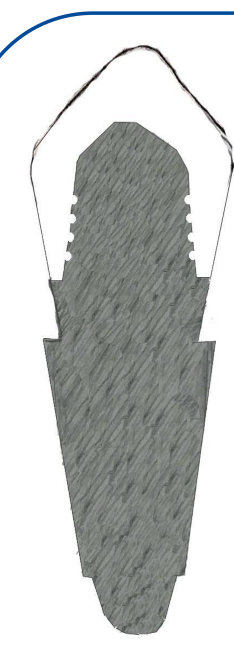


Figure 7 Silhouette, original design

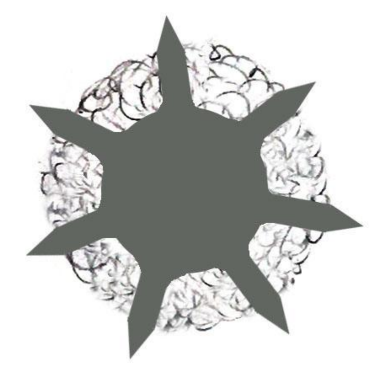


Figure 8 Horizontal cross-section, original design

- 7 knife-edged fins topped into the bone achieve primary stability and lifelong anchorage
- Fins, core, apex, abutment and trabecular structures are printed as patient-specific one-piece implant to improve strength and reduce common implant failures
- Trabecular structure between fins mimics cancellous bone to promote osseointegration.
- Abutment grooves (optional design) improve crown cementation and retention.

BACKGROUND

A dental Implant is typically a titanium post surgically positioned in the bone beneath the gingiva. It serves as an anchor to support and retain prosthetic restoration. The multiple stages of case planning often require 6-12 months to complete. Stability and material biocompatibility are essential in achieving successful osseointegration. The proposed material for a new implant designed by RD&B team is titanium porous oxide which bonds the trabecular structure of the implant with the bone.

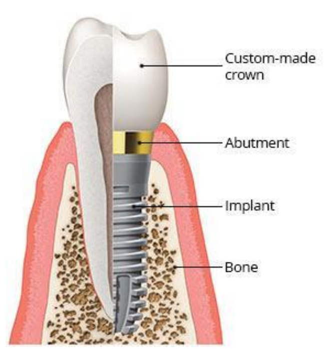


Figure 2 (Sectional view of an endosteal dental implant alongside a natural tooth)

DIGITAL PROTOTYPES

Even though scanning provides the most accurate means to make CAD design of a natural tooth, there are still fixtures and tares in the design that need to be repaired utilizing Autodesk's Meshmixer. Figures 9-12.

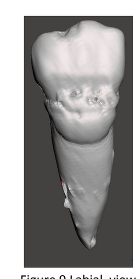


Figure 9 Labial view of tooth before correcting the fixtures

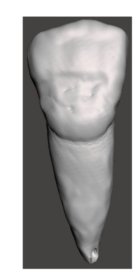


Figure 10 (Labial view of tooth after correcting the fixtures)


Figure 11 Proximal view of tooth before correcting the fixtures

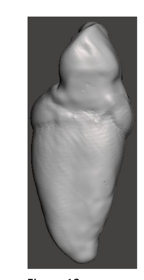


Figure 12 (Proximal view of tooth after correcting the fixtures)

After cleaning the scan with Meshmixer software, the Fusion 360 software is required to transfer of the design from STL format to a file which can be edited as a geometric shape. Figures 13-15

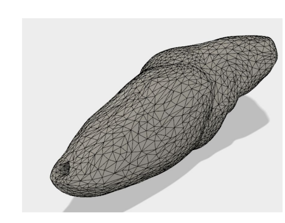


Figure 13 Converted full tooth from STL to Geometric part

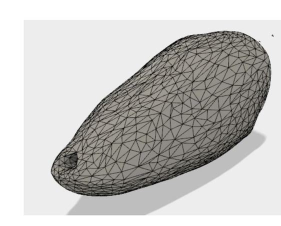


Figure 14 Root of abutment

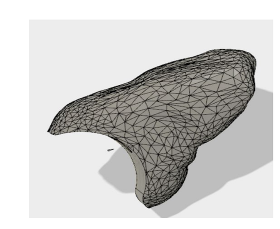


Figure 15 Crown of the abutment

OBJECTIVES

- Create one piece custom designed and printed immediate loading implant to eliminate micro-leakage and reduce implant failures.
- Reduce trauma and shorten the implant osseointegration timeline for the patient.
- Decrease treatment planning timeline for dental professionals.

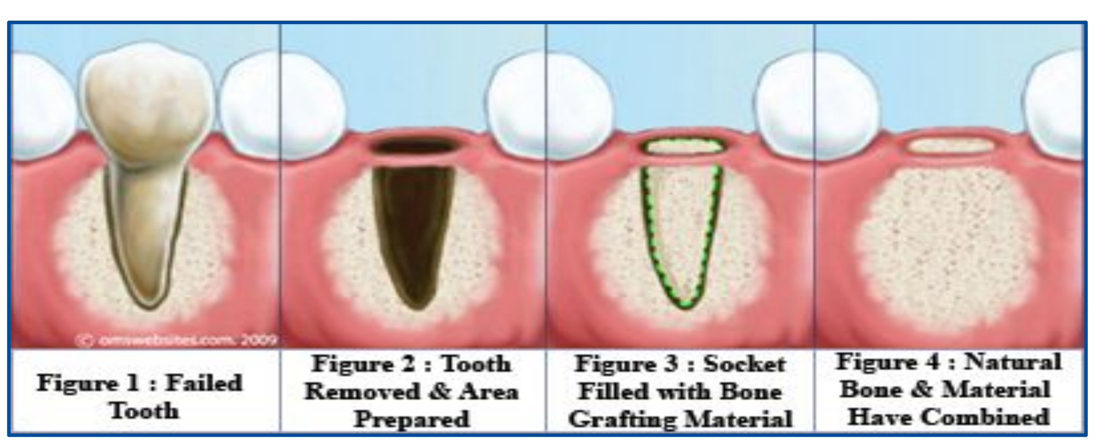



figure 4, implant prototype, original design

RESULTS

The geometric shape is sculpted and edges get rounded to mimic the natural shape of the tooth. Seven fins are added to the root (size of fins may vary according to shape and bone density) and the height of the coronal portion of the tooth is reduced 1.5 mm to recreate substructure to later cement the final restoration. Figures 16-19


Figure 16 Labial view adaptation


Figure 17 Lingual view adaptation


Figure 18 Mesial view adaptation


Figure 19 Angled view adaptation

METHOD

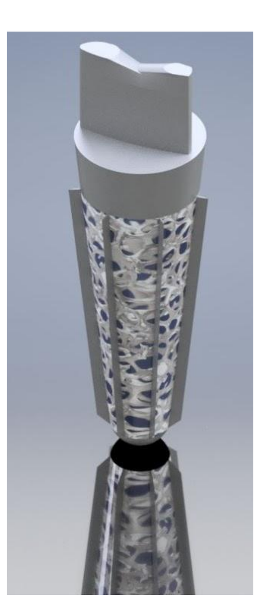


Figure 5 Elemental mock-up, original design


Figure 6, 2nd Premolar Crown, original design

- Utilize CT Scans of a patient's dental alveoli prior to surgery to create custom fit implants.
- Use CAD/CAM methods to design and print a single component titanium implant
  - Decrease chance of infections by eliminating the opportunity for micro-movements and micro-leakage between multiple part
  - Eliminate trauma from drilling with a minimally invasive tap-in implant placed at the time of extraction
- Improve osseointegration by incorporating trabecular structure
- Provide stability and anchorage by incorporating the 7 fin implant design.

OSSEOINTEGRATION

New developments aid with improved osseointegration of the implant at the extraction site:

Clinicians added autogenous bone or a synthetic material into the osteotomy site to induce bone formation at the most apical portion. Materials used for osseointegration are divided into natural transplants (autografts, allografts, and xenografts) and synthetic materials (alloplasts). These graft materials are used for clinical applications based on the hypothesis that they are osteogenic, osteoinductive, osteoconductive or possess a combination of these properties. The use of allografts, xenografts, and alloplasts has all generated remarkable results.

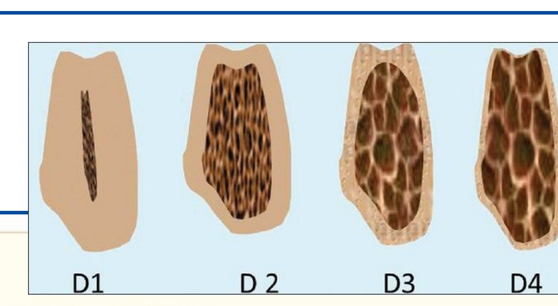


Table 1

Bone replacement graft tissues and materials.

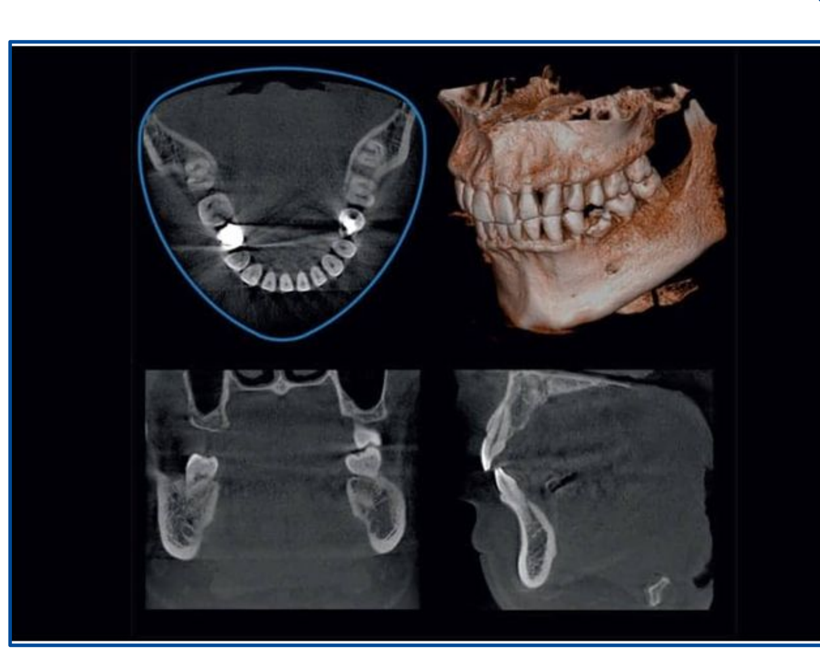
Human bone sources		Non-human natural sources	Synthetic sources (Alloplasts)	
Autografts	Allografts	Xenografts	Bioactive glasses	Bioceramics
-Extra oral sites	-Fresh frozen bone	-Bovine Hydroxyapatite	–	-Hydroxyapatite
-Intra oral sites	-Freeze dried bone allograft (FDBA)	-Coralline calcium carbonate	–	-Other calcium phosphates (Tricalcium phosphate, brushite, monetite)
–	-Demineralized freeze dried bone allograft (FDBA)	–	–	

Planning

CT and CBCT scans allow for the view of the patient's anatomy that when properly utilized remove the guesswork associated with placing implants, empowers clinicians with enhanced diagnostic information, aids the process of making informed decisions for their patients, and provides an improved foundation for communication between all members of the implant team.

CT/CBCT scan technology creates precise measurements of height, width, and depth of the bone, in addition to diagnostic information regarding bone density. Diagnostic imaging technology further enhanced by software applications allows for true interactive CT scan computer-based treatment planning in all dimensions prior to surgery, and the fabrication of surgical guides that link the data to the patient. This technology is invaluable for assessing donor and receptor sites for bone grafting, sinus augmentations, third molar extractions, orthognathic surgery, and orthodontics.

For dental implant placement, CAD/CAM derived surgical templates allow the highest degree of accuracy in transferring the treatment plan to the patient at the time of surgery.



CONCLUSION

Today, dental implants extend the range of care to a variety of patients undergoing necessary prosthodontic rehabilitation. If the benefits of such treatments are to be maximized, the implants must be selected on logical basis and placed within the context of the full range of treatment modalities. However, modern dental implant systems are based on multiple components often leading to micro-movements and micro-leakage which cause stress on the bone and bacterial infections, both of which compromise the success of osseointegration and consequently jeopardize the whole implant adaptation. Thus, a new idea of patient-specific one-piece immediate loading implant emerged to reduce the micro-movement, shorten healing time and number of visits, and contribute to lesser implant failures. The prototypes of the seven-fin trabecular structure implant will be customizable for individual patient using the design software and 3D printing technology. The osseointegration phase will rely on the best materials and techniques to induce bone formation at the osteotomy site. The final components will include the titanium implant and coronal restoration designed with specifications, measurements, and proportions in accordance with the morphology and function of the natural teeth.

Sources:

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More sources can be found on link provided for google drive: https://docs.google.com/presentation/d/12fVVFioAe5hjiXufgLZTy0cWczAFy3Q_2zMbWwq8Pfo/edit#slide=id.p66

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