



Lock Washer for Dental Implant-supported Restorations

October 6, 2023

Client: Dr. Donald Tipple - owner of Nakoma Dental

Advisor: Dr. John Puccinelli

Team: Maggie McDevitt, Isabelle Peters, Kennedy Young,
Caroline Davis, Jacki Szelagowski, Aaron Marattil

Overview

- Problem Statement
- Background: Dental Implants
- Background: Competing Designs
- Preliminary Design Specifications
- Design Matrix: Material
- Design Matrix: Washer Type
- Future Work
- References

Problem Statement

Client

Dr. Donald Tipple

Title

Dentistry
Practitioner

Affiliation

Nakoma Dental

Motivation

- After a dental implant surgery, the patient's mouth is restored by a screw torqued up to 35 Ncm
- Most common failure is the loosening of the screw
- Design an improved lock washer and screw method to better withstand occlusal forces from everyday actions
- Goal: to create a dependable solution to reduce dental implants becoming dislodged

Background

Dental Implants

- Why people get them
 - Prevents jawbone from shrinking
 - Preserves health of surrounding bone
 - Keeps nearby teeth stable
 - Improve quality of life [1]
- The dental screw
 - Implanted into the jawbone and holds the abutment and crown in place
 - About one patient per year experiences screw loosening
- Hypothesize that the lock washer will prevent the screw from loosening

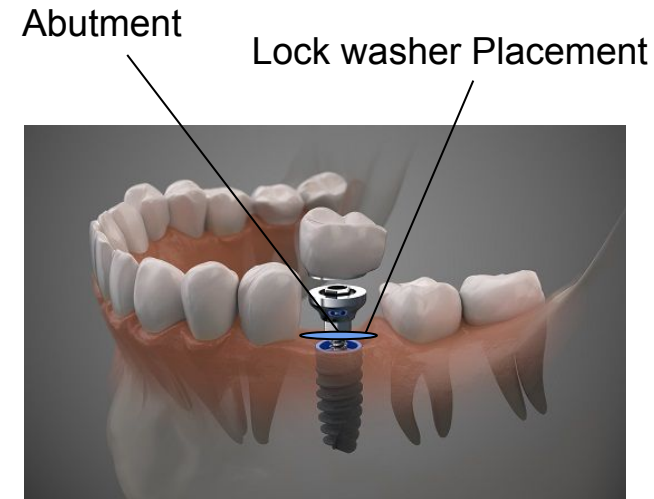


Figure 1: Image of Dental Implant [2]

Background - Competing Designs

- Anti-Slippage Mechanism for Dental Implant Components
 - A spring washer is placed between the abutment and fixture to prevent the screw from loosening
 - Main difference between our design and this is the placement of the lock washer [3]
- Abutment Screw with Spring Lock Washer
 - Spring washer has a surrounding ring with legs extending to aid in preventing the screw from coming loose [4]

U.S. Patent Jan. 9, 1996 Sheet 3 of 3 5,482,463

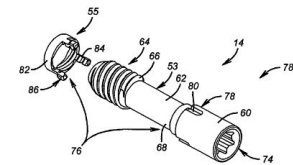
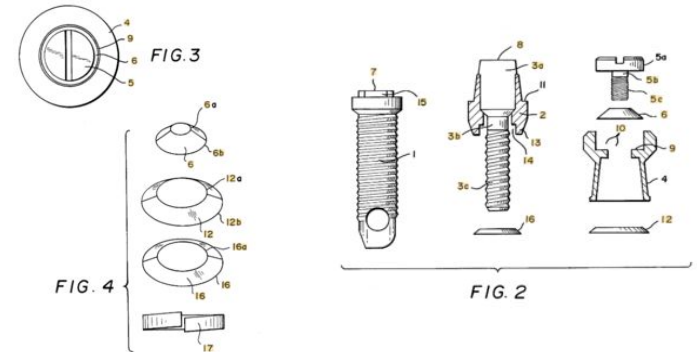


FIG. 4

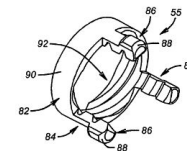


FIG. 5

Figures 2, 3, 4: Washer Placement [3]

Preliminary Design Specifications

- Last 10-15 years without deterioration [5].
- Screw is torqued 35 Ncm (initial tightening)
 - Washer should resist torque in the opposite direction
 - Withstand occlusal forces
- Size:
 - Inner diameter: 1.4 mm
 - Outer diameter: < 2 mm
 - Height: likely < 1/4 mm
- Metal material
 - Biocompatibility, osseointegration, corrosion resistance

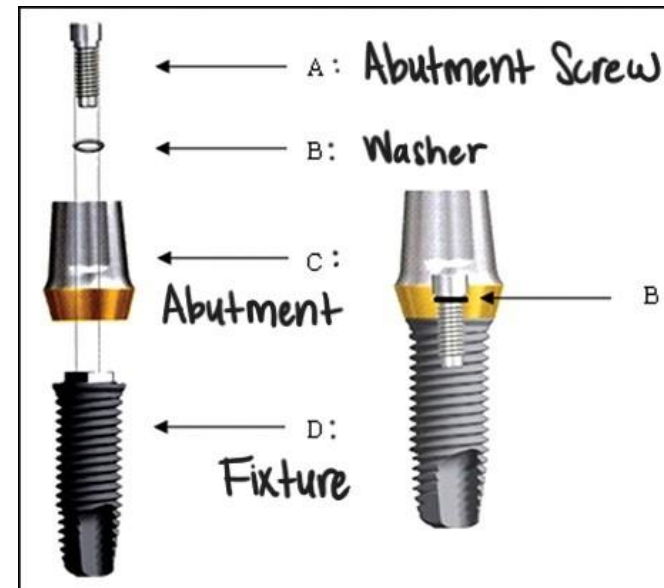


Figure 5: Fixture-abutment complex with washer [6]

Pure Titanium

- Commonly used in dentistry- biocompatible
- Affordable
- Least strong out of the three materials
- Not very aesthetically pleasing

Titanium Alloy

- Very strong
- Long lasting
- Biocompatible
- Not very aesthetically pleasing

Zirconia

- Tooth-like appearance
- No metal-to-metal interactions
- Not as long lasting
- More expensive




Designs/ Design Matrices Material

Criteria (Weight)	Pure Titanium		Titanium Alloy		Zirconia	
Strength (40)	3/5	24	5/5	40	4/5	32
Longevity/ Durability (25)	4/5	20	5/5	25	3/5	15
Biocompatibility (15)	5/5	15	5/5	15	4/5	12
Safety (10)	4/5	8	4/5	8	5/5	10
Aesthetics (5)	3/5	3	3/5	3	5/5	5
Cost (5)	5/5	5	4/5	4	3/5	3
Total (100)	75		95		77	

Material Selection

- Titanium Alloy
 - Stronger
 - Longer lasting
 - Biocompatible

Design Matrices Washer - Total

Criteria (Weight)	Split Lock Washer		External Tooth Lock Washer		Conical Washer	
	 <i>Figure 1: Split Lock Washer</i>		 <i>Figure 2: External Tooth Lock Washer [1]</i>		 <i>Figure 3: Conical Washer [2]</i>	
Resistance to Torque (40)	4/5	32	3/5	24	3/5	24
Versatility (25)	5/5	25	1/5	5	4/5	20
Ease of Fabrication (20)	4/5	16	4/5	16	4/5	16
Safety (10)	4/5	8	3/5	6	4/5	8
Cost (5)	5/5	5	4/5	4	3/5	3
Total (100)	86		55		71	

Future Work

- Reach out to faculty in the Materials Science department
- Look into fabrication methods on campus
- Look into 3D printing companies who manufacture titanium
(Protolabs, Sculpteo, etc.)
- Potential torque testing

References

- [1] Center for Devices and Radiological Health, “Dental implants: What you should know,” U.S. Food and Drug Administration, <https://www.fda.gov/medical-devices/dental-devices/dental-implants-what-you-should-know#:~:text=Helps%20keep%20the%20jaw%20bone%20from,Improves%20quality%20of%20life> (accessed Oct. 4, 2023).
- [2] The Dental Place of Tamarac, “How an implant crown is attached,” The Dental Place of Tamarac Tamarac Florida, <https://thedentalplaceoftamarac.com/blog/how-an-implant-crown-is-attached/amp/> (accessed Oct. 4, 2023).
- [3] R. S. Wilson, “US5482463A - Anti-slippage mechanism for dental implant components,” Google Patents, <https://patents.google.com/patent/US5482463A/en> (accessed Sep. 21, 2023).
- [4] I. Aravena and A. Kumar, “US7300283B2 - abutment screw with Spring-Washer,” Google Patents, <https://patents.google.com/patent/US7300283B2/en> (accessed Oct. 4, 2023).
- [5] “Straumann® Products and Solutions.” Accessed: Sep. 20, 2023. [Online]. Available: <https://www.straumann.com/en/dental-professionals/products-and-solutions.html>
- [6] O. Jamiyandorj, S. Kim, J.-S. Shim, and K.-W. Lee, “Effect of Using a Titanium Washer on the Removal Torque of an Abutment Screw in the External Connection Type of Dental Implant,” *Implant Dentistry*, vol. 21, no. 2, p. 156, Apr. 2012, doi: [10.1097/ID.0b013e31824a02b9](https://doi.org/10.1097/ID.0b013e31824a02b9).