SUBCRESTAL IMPLANT PLACEMENT AND ITS EFFECT ON CRESTAL BONE LEVELS: A CLINICAL STUDY IN DOGS

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2013

This paper is dedicated to my wife, my family, and to dogs.

ACKNOWLEDGMENTS

I would like to thank Dr. Neiva, Dr. Koutouzis, Dr. Wallet and the entire faculty of University of Florida College of Dentistry for guiding me through my periodontal education. I would also like to thank the University of Florida for letting me earn three degrees, winning four National Championships, and helping me become the man I am today

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AM	Abutment Margin
BOP	Bleeding on probing
CB	Crestal Bone
IP	Implant Platform
KG	Keratinized Gingiva
PD	Probing Depth

Abstract of Thesis Presented to the Graduate School
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May 2013

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Major: Dental Sciences – Periodontics

Implant design and implant abutment interface have an influence on crestal bone levels. The Ankylos implant has been shown to maintain crestal bone levels even when placed subcrestal. The aim of the present study was to determine crestal bone changes around Ankylos implants placed at different depths subcrestally.

Thirty-six two-piece dental implants with a centralized implant-abutment interface and Morse taper connection were placed in edentulous areas bilaterally in six mongrel dogs. At each side of the mandible, three implants were placed randomly at the crest of bone, 1.5mm subcrestal, or 3.0mm subcrestal. After 12 weeks final abutments were torqued into place. At 24 weeks the animals were sacrificed and samples taken for histology. Radiographs and clinical measurements were taken at time of implant and final abutment placement.

Clinical analysis revealed very little bone loss around any of the implants. Subcrestal implant lost slightly less crestal bone than crestal placed control implants. Subcrestally placed implants maintained the bone well crestal to the implant and lost no

bone around the implant body. No clinically significant differences regarding marginal bone loss between the implant depths.

Implants with a centralized implant-abutment interface and Morse taper connection can be placed subcrestal without significant loss of crestal bone. It may be preferable to place these implants subcrestal to preserve bone to implant contact

CHAPTER 1
INTRODUCTION

Dental implants are a viable and popular form of tooth replacement. Over the past 30 years, research has validated the success of osseointegrated implants as an alternative to removable, or tooth-borne, prosthetic restorations. Although techniques and materials have been developed which are capable of a high degree of clinical success, the ultimate long-term success of implants is dependent upon the efforts of both the patient and dentist in maintaining the health of the peri-implant tissues (Albrektsson 1986).

Several factors contribute to the success and failure of a dental implant. One such factor is the bone support surrounding the implant especially in relation to bone levels at the bone crest adjacent to the implant. A zone of epithelium and connective tissue integration form “biologic width” surrounding and protecting an abutment and implant from pathologic insults. It has been found that if the biologic width is altered in an apical direction a corresponding marginal bone loss will also occur. This area of bone loss is usually found to start at the implant abutment interface (Berglundh and Lindhe 1996)(McKinney et al. 1984).

The Ankylos implant system features a precision-machined, internal tapered abutment connection that eliminates the microgap found in most two-stage implant designs. It also features a narrow, medialized, abutment that allows for bone growth onto the abutment platform. The design of this implant is to reduce bone loss, and allow for subcrestal implant placement (Doring 2004).

The aim of this study was to evaluate crestal bone remodeling following Ankylos implant placement at varying depths subcrestally in the canine model. Clinical data would be collected at the second stage surgery. We hypothesized that bone loss would remain similar for the different subcrestal groups and the implants would maintain bone crest height over time.

CHAPTER 2
BACKGROUND

Platform Switch

Early implant-abutment designs have an interface with an external connection and abutment walls that were the same diameter as the implant. These connections have a micromovement engineered into there design. This movement leads to bacterial contamination at the interface and an associated inflammatory infiltrate. This zone of inflammatory infiltrate can lead to bone loss at the implant-abutment interface (Cochran 2009).

Several methods have been used to prevent bone loss from the area of the implant-abutment interface. One such method is to centrally locate the margin of the abutment on the platform of the implant. This technique is known as platform switching (Lazzara 2006). This method moves the zone of irritation of the interface further from the bone and results in less bone loss than an interface that is flush between the implant and abutment (Enkling 2011)(Lazzara 2006).

Another technique used in implant design to limit the irritation caused at the implant abutment margin is to use an internal connection in conjunction with a centrally located margin of abutment. Such a configuration can result in a more stable connection that does not allow contamination of the interface. These connections have been shown to lose less marginal bone than external, non-centrally located, abutment connections (Jung 2008).

Influence of the Microgap

Bacterial colonization of the peri-implant tissues occurs within minutes of implant placement (Fürst 2007). These microorganisms may establish colonies at the implant-abutment interface, or the microgap (Quirynen 2006). These microbial colonies may lead to inflammation around the peri-implant tissues, and eventually bone loss, around the implant (Hermann 2001). Preventing the inflammatory effect of microbial contamination at the microgap is important in the design of two-piece implant systems (Koutouzis 2011).

Tissue level implants with an implant-abutment interface located greater than 1 mm from the bone crest have been found to lose minimal to no bone (Hermann 2000). When two-piece implants with the implant-abutment interface at bone level are placed, even in a one-stage approach, bone is lost at the crest (Albrektsson 1986). Two piece implants placed with the implant-abutment interface placed 1 mm below the bone crest tend to lose even more bone than those placed at the bone crest (Cochran 2009)(Becker 1997). These findings support that the implant-abutment interface influences the amount of bone resorption around implants over time.

Subcrestal Implant Placement

Placing an implant-abutment interface apical to the crest of bone, or subcrestal implant placement, has many proposed advantages. Placing an implant apical to the bone will decrease the risk of exposure of the metal top of the implant or the abutment margin, thus preventing contamination of the surface of the implant (Novaes 2006). It will allow sufficient space vertically to create an appropriate esthetic emergence profile even with a large platform switch. Subcrestal implant placement could allow implants to be placed more adjacent to each other by limiting the cumulative effect of their microgap (Novaes 2009)(Barros 2010).

Subcrestal implant placement can result in more crestal bone loss than equicrestal placement due to the microgap. Several studies have found that the greater the inflammation at the microgap the greater the bone loss (Cochran 2009). To successfully place an implant subcrestally, the inflammation from the microgap must be minimal to none, or more bone loss will occur (Degidi 2011). In vitro strain finite element analyses has shown a depth of .5-2.5mm subcrestal to be the most ideal for stress distribution (Chu 2011).

The Ankylos Implant System

The Ankylos dental implant system has been used for tooth replacement since 2004 (Doring 2004). It has many attributes that make it uniquely adapted for subcrestal implant placement by minimizing the detrimental effects of a microgap and micromovement. The Ankylos implant-abutment interface is a precision Morse taper that produces a bacteria resistant connection (Aloise 2010)(Tesmer 2009)(Koutouzis 2011a). This Morse taper allows the abutment to fit so precisely to the implant that no microgap or micromovement occur under normal forces (Zipprich 2007). The implant has an aggressive platform switch that allows for room for CT and bone over the implant platform and space from the implant-abutment connection (Degidi 2008).

These characteristics of the Ankylos implant system allow for subcrestal placement without corresponding bone loss around the implant margin caused by the microgap present in most implant systems (Donovan 2010)(Koutouzis 2011). It is not currently known if there is an ideal subcrestal depth. The objective of the present study is to examine the effect of the Ankylos implant placed at different depths subcrestally.

CHAPTER 3
MATERIALS AND METHODS

Animal Care

Six female hound type dogs of approximately 25-30kg greater than 2 years of age are to be the subjects of the experiment. Protocol will be modeled after a previous similar study (Hermann et al. 1997) (Figure 3-1). Regular feeding, activities, and veterinary care will be provided by the University of Florida department of Animal Care Services. The candidate, using tramadol, and buprenorphine, will administer postoperative pain management. The dogs will be fed soft diet, after the first surgery, consisting of canned dog food or moistened, previous dried dog food.

First Surgery: Premolar Extractions

The first procedure will be to surgically extract all eight mandibular premolars from each dog, under general anesthesia. Impressions to be taken using compound material for radiographic stent fabrication. Antibiotics and anti-inflammatory medications will be given before and following surgical procedures.

Second Surgery: Implant Placement

Following a healing period of three months a second surgical procedure will be performed. Antibiotics and anti-inflammatory medications will be given before and following surgical procedures. The edentulous ridge is flattened with a high-speed handpiece with a flat diamond bur, and six Ankylos A9.5 (Prod no. 3101 0208) implants are to be placed per dog for a total of 36 implants. At each side of the mandibular arch three implants will be placed 0mm, 1.5mm, or 3mm subcrestally, and will be assigned in a random order (Figure 3-2). Sulcus forming abutments will be placed at time of surgery in the two test implants (1.5, and 3.0, product no. 3102 1530, and 3102 1535).

The control, equicrestal, implant will receive the covers crew provided in the implant packaging (Figure 3-3). The site will then be sutured to obtain primary closure. Baseline radiographs will be taken after surgery using radiographic stent and paralleling technique. All implant procedures will be completed using manufacturers guidelines.

Third Surgery: Abutment Placement

Three months post implant placement the implants will be accessed by gingival punch, and sulcus formers removed at 5Ncm increments to determine removal torque. Each implant will receive a straight stock abutment. Implants placed; equicrestal will receive an Ankylos (a/1.5/4.0) abutment; 1.5mm subcrestally will receive an Ankylos (a/3.0/4.0) abutment; and 3.0mm subcrestally will receive an Ankylos (A/4.5/4.0) abutment. The most coronal height of all abutments will be at the same level (Figure 3-4).

Mesial, distal, buccal, and lingual cortical bone measurements at the crest will be taken using a periodontal probe (UNC15) measuring from the abutment margin directly apical to the bone crest. The measurements will be taken by one operator and rounded to the nearest half millimeter. BOP, PD, and KG will be recorded as applicable. Radiographs to be taken using radiographic stent and paralleling technique. All abutments will be placed to manufacturers recommendations in all procedures.

Data Analysis

Clinical data will be analyzed for bone and soft tissue positions around implant. Clinical bone level findings will be arranged and averaged using Microsoft Excel software, and analyzed via one-way ANOVA with Bonferroni’s multiple comparison test for significance. Clinical bone levels will be compared at baseline and three months Clinical measurements of mesial, distal, labial, and lingual cortical bone levels taken at time of implant placement will be compared to the same measurements after three months.

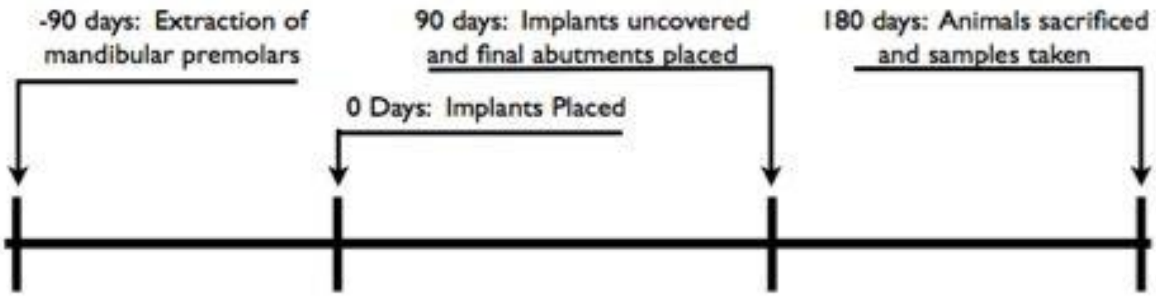

Figure 3-1. Timeline of Procedure.

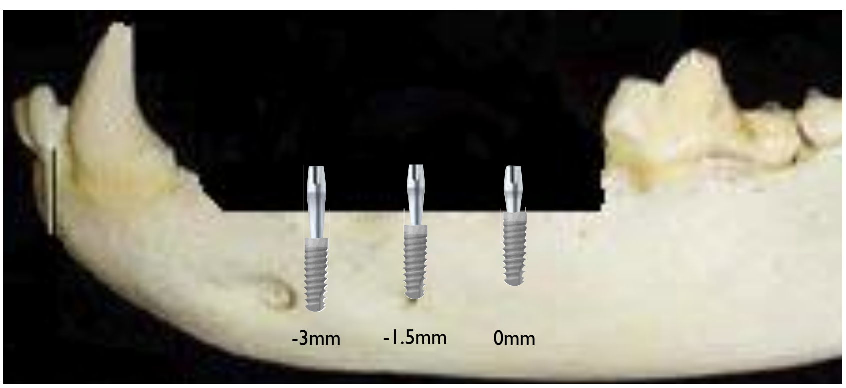

Figure 3-2. Schematic of implant placement with final abutments.

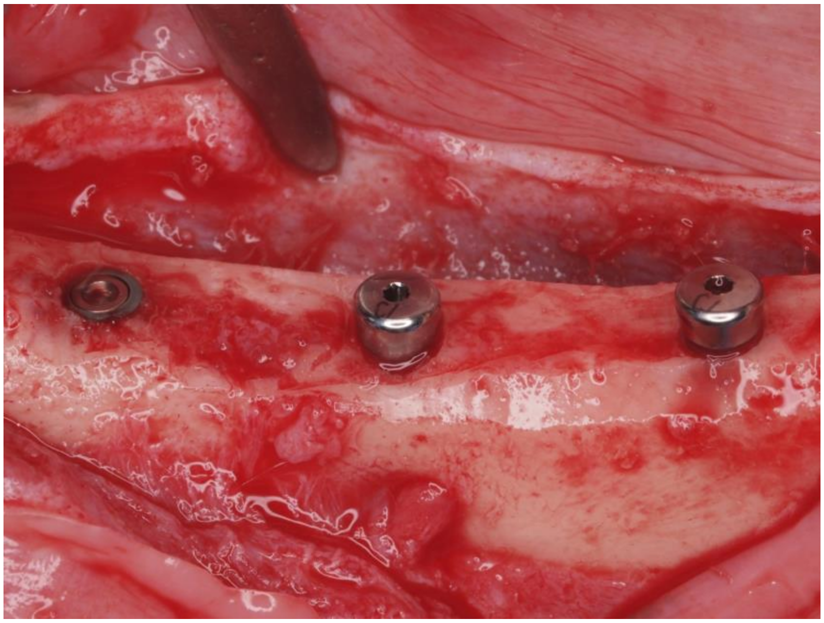

Figure 3-3 Implants placed in flattened crest. The control implant has a cover screw. The test implants have sulcus formers to equalize the occlusal height.

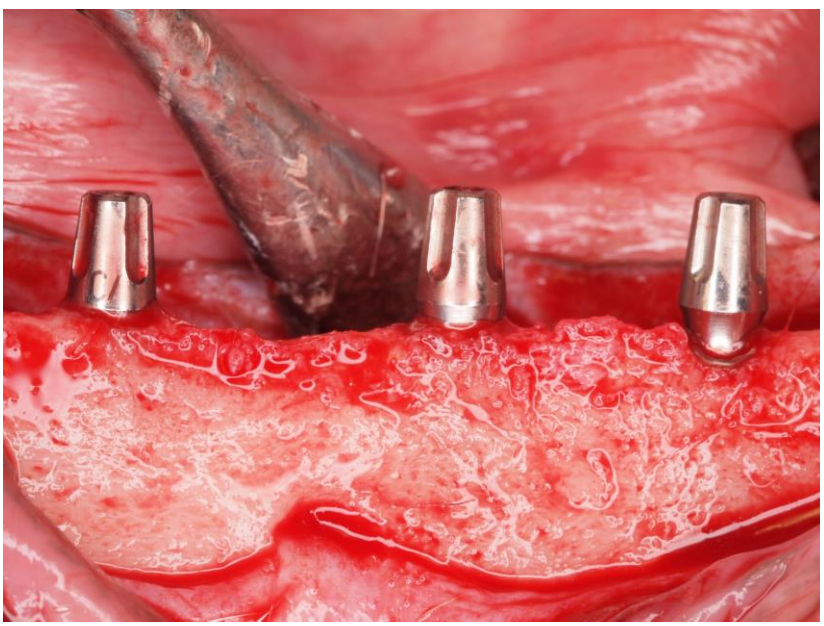

Figure 3-4 Implants with final abutments placed. Abutment heights are level occlusally.

CHAPTER 4
RESULTS

One implant failed to osseointegrate in each group. Implant survival rate was 91.7%. Sulcus former average removal torque in the 1.5mm subcrestal group was 10.83 Ncm and 10.91 Ncm in the 3.0mm subcrestal group. The difference in sulcus former removal torque was not significant between groups and is shown in Table 4-1. Table 4-2 illustrates sulcus former exposure by implant. The control group with cover screws shows no implants exposed transmucosally. The 1.5mm subcrestal group had one sulcus former exposed transmucosally with an average probing depth of 2mm. The 3mm subcrestal group had three sulcus formers exposed transmucosally with an average probing depth of 2.33mm.

Figure 4-1 shows the distribution of crestal bone changes in each group. All groups averaged crestal bone loss. The 1.5mm subcrestal group lost the least amount of bone on average. Table 4-3 shows the mean bone loss in each group and the mean remaining bone above the platform. Only the control group did not have any bone remaining above the platform. Both the 1.5mm subcrestal group and the 3.0mm subcrestal group maintained the majority of the bone above the platform. Analysis of the means via one-way ANOVA with Bonferroni's multiple comparison test for significance failed to show a significant difference between groups (Figure 4-4). The greatest difference in bone levels between groups was between the control and the 1.5mm subcrestal group with a mean difference of -0.18mm.

Table 4-1. Mean removal torque of sulcus formers in the two test groups

Implant Depth	Mean Removal Torque
1.5	10.83333333
3	10.90909091

Table 4-2. Sulcus former exposure transmucosally by implant with probing depth

Baseline Platform Depth	Number of Sulcus Formers Exposed	Mean PD
0	0	0
1.5	1	2
3	3	2.33

Table 4-3. Mean change in crestal bone level and mean remaining bone above platform.

Platform Depth	N	Mean Change in Crestal Bone Level	Mean Remaining Bone Above Platform
0mm	11	-0.41mm	-0.41mm
-1.5mm	11	-0.23mm	1.27mm
-3.0mm	11	-0.36mm	2.64mm

Table 4-4. Bonferroni's multiple comparison test between groups showed no significant difference in mean crestal bone loss.

Bonferroni's Multiple Comparison Test	Mean Diff.	t	Significant P < 0.05	Summary	95% CI of diff
0mm vs -1.5mm	-0.1818	0.6421	No	ns	-0.8998 to 0.5362
0mm vs -3.0mm	-0.04591	0.1621	No	ns	-0.7639 to 0.6721
-1.5mm vs -3.0mm	0.1359	0.4800	No	ns	-0.5821 to 0.8539

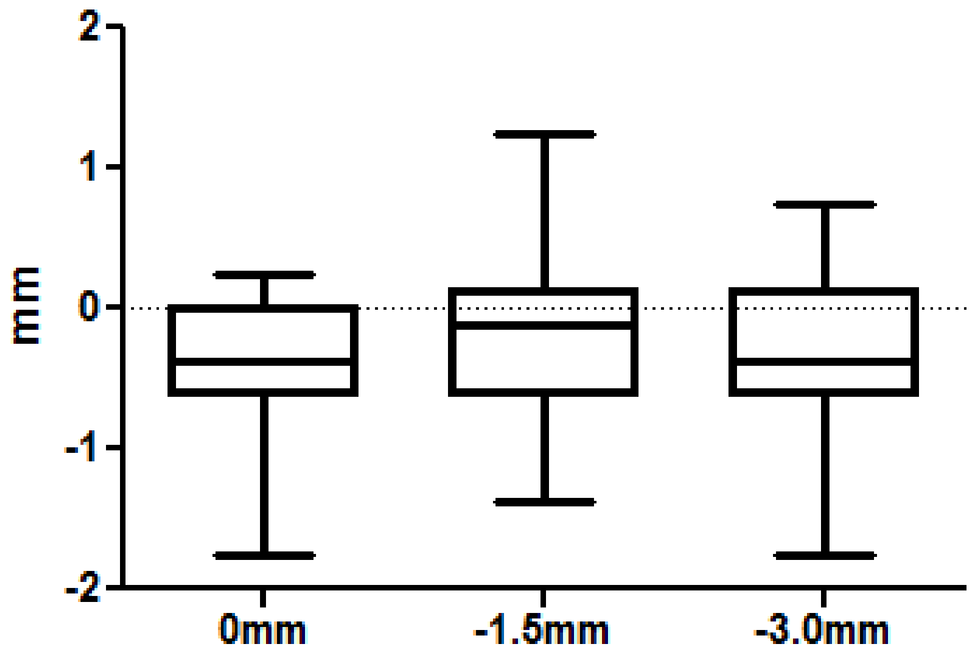

Figure 4-1 Crestal bone changes at 3 months post implant placement by group.

CHAPTER 5
DISCUSSION

Subcrestal placement of most bone level implants has been shown to lead to greater bone loss than crestal, or supracrestal implant placement (Cochran 2009)(Hartman 2004). The present study has shown that an implant with a connection that minimizes the microgap, has minimal micromovement, and that has a large platform switch, can have the same amount of crestal bone loss if placed at the crest of bone or up to 3mm subcrestal. The bone loss of the control implant is consistent with similar studies in which two-piece implants are placed at the crest of bone (Cochran 2009).

The two test implants showed less bone loss than similar implants placed subcrestally in the canine model (Cochran 2009)(Hermann 2000). This difference is probably due to the factors, which allow this implant to reduce the effects of the microgap. The strong Morse taper connection reduces the bacterial inflow into a microgap which will cause less inflammation in the area, and thus limit bone loss. The large platform switch will reduce the effects felt from any irritation at the microgap by means of distancing it from the surrounding bone. These factors probably allow the Ankylos implant to be placed subcrestal with minimal effects on the surrounding bone.

Bone loss around implants occurs less than three months after they are placed (Cochran 2009)(Hermann 2001)(Hermann 2000). The implants in this study also showed bone loss and remodeling within the first three months. There was no significant difference in the amount of bone loss between the implant groups in this study, regardless of the depth of placement. This bone loss may be explained by the normal physiologic bone loss following full thickness flap elevation (Wood 1972). The bone loss present in all groups could also be a result of the microgap and irritation caused by it, although this was less than similar studies.

A previous study has shown that there may be histologically intimate contact between bone and sulcus former in implants placed subcrestally (Degidi 2011). In the present study there was no difference in sulcus former removal torque regardless of the depth. This indicates that there is no osseointegration of the sulcus former in these implants, regardless of depth. This may be due to the fact that the sulcus former is a polished titanium and unable to create enough bone to titanium contact on the sulcus former to affect removal torque. Clinically a thin layer of periosteum-like soft tissue was found around the sulcus former once it was removed. This soft tissue may have migrated in rapidly after implant placement and prevented any bone to contact the sulcus former.

To the authors knowledge there is not a clinical trial with implants placed 3mm subcrestal. This study has shown implants, that limit the effect of the microgap, can be placed up to 3mm subcrestal without any more bone loss than implants placed at the bone crest. The bone above the platform at placement is maintained in these implants. This bone can be used to create esthetic results by masking the titanium color of the implant, supporting adjacent soft tissue papilla, and allowing room for emergence profile (Doring 2004).

This study had several limitations. The implants were not directly loaded. Most of the implants had a layer of gingiva covering the sulcus former. The findings only represent three months of healing. More studies need to be done to investigate the effects of the Ankylos implant other similar implants placed subcrestal and loaded over time.

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BIOGRAPHICAL SKETCH

Michael Fetner was born in Jacksonville, Florida. He is a three time Gator having graduated from the University of Florida with a B.S. in microbiology, a D.M.D. from the College of Dentistry, and soon to have a M.S. from the Department of Periodontics. He plans to move to Jacksonville with his lovely wife Sondra Randon Fetner and continue his parent's work in a private practice periodontal office. He enjoys biking, reading, video games, and travel.