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Effect of a Two Piece Scalloped Implant Design on Interproximal Bone Apposition/Retention - A Pilot Study in Rabbits

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LOMA LINDA UNIVERSITY
School of Dentistry
in conjunction with the
Faculty of Graduate Studies

Effect of a Two Piece Scalloped Implant Design on Interproximal Bone Apposition / Retention – A Pilot Study in Rabbits

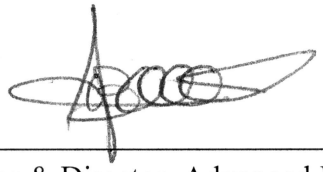
by

Aladdin Jamal Al-Ardah

A Dissertation submitted in partial satisfaction of
the requirements for the degree of
Master of Science in Implant Dentistry

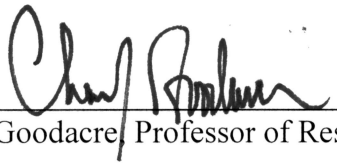
March 2009

Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree Master of Science



_____, Chairperson

Jaime L. Lozada, Professor & Director, Advanced Education in Implant Dentistry



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Charles J. Goodacre, Professor of Restorative Dentistry & Dean of the School of Dentistry

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Periklis Proussaefs, Assistant Professor, Advanced Education in Implant Dentistry

In memory of Dr. Philip J. Boyne.

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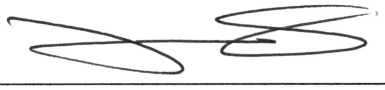
Philip J. Boyne, Emeritus Professor of Oral Maxillofacial Surgery



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Juan C Abarno, Dentist in Private Practice, Salto, Uruguay

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ABSTRACT

Effect of a Two Piece Scalloped Implant Design on Interproximal Bone Apposition / Retention – A Pilot Study in Rabbits

by

Aladdin Jamal Al-Ardah

Master of Science, Graduate Program in Implant Dentistry
Loma Linda University, March 2009
Dr. Jaime Lozada, Chairperson

The aim of the study was to evaluate the effect of an experimental two piece scalloped implant design with a scalloped elliptical coronal part and an HA surface treatment on the bone to implant contact percentage in comparison to a commercially available HA treated implant. The possibility of bone apposition / retention along the exposed coronal scalloped part and the effect of the presence of a junction on the bone to implant contact percentage and bone apposition / retention were analyzed. 10 rabbits were included in the study with each rabbit receiving one control implant in one tibia and one experimental implant (experimental implant) in the other. Rabbits were divided in two groups:

Group one: consisted of 6 rabbits. The experimental implants were placed with all second scalloped part (4mm) above the existing bone level compared to the control implant that received a 3mm healing abutment placed above the existing bone level. No membrane or grafting material was used and the periosteam and tissue were sutured over the implants.

Group two: Consisted of 4 rabbits. The experimental implants were placed with only the scalloped platform (2mm) above the existing bone level compared to the control implants that received a cover screw. No membrane or grafting material was used and the

periosteam and tissue were sutured over the implants. Sites were allowed to heal for 27days after which the animals were sacrificed and gross samples were prepared and sent for histomorphometric analysis. BIC% was measured twice for each group, once from the top of the implant to the inferior border of the superior cortical plane and the second over the whole length of the implant. The effect of the presence of a junction between the implant parts and the level of the junction in relation to bone apposition was evaluated. There was no statistically significant difference between the BIC% of the implants and the control implants in both groups one and two, however the bone was better adapted along the second scalloped part of the experimental implant than around the healing abutment of the control implant. It was also possible to gain bone apposition / retention around the second part of the experimental implant and beyond the existing native bone level provided that space can be maintained; it was consistent up to 2mm above the native bone level. The presence of a junction between part one and part two had no effect on bone apposition / retention.

CHAPTER ONE

INTRODUCTION

Endeosseous root form dental implants have become an accepted modality for replacing single [1, 2, 3, 4] and multiple missing teeth [5, 6, 7]. Since their introduction one of the major goals that must be attained upon their placement is osseointigration. Albrektsson and coworkers [8] have suggested six main factors that are most important to successful implant osseointegration. These factors are:

1. Biocompatibility of the implant material.
2. Implant geometry.
3. Implant surface characteristics.
4. Surgical technique.
5. Bone condition (implant bed condition).
6. Implant loading conditions.

Since their introduction, implants have evolved in design and surgical techniques have been mastered that have produced a very predictable modality for the replacement of missing teeth. One of the most challenging implant procedures is that of replacing single teeth in the esthetic region [9]. The challenging task in these situations is creating and maintaining the soft tissue around the margins of the implant. After the loss of an anterior tooth the sequelae of healing leads to resorption of crestal and interdental bone and to recession of the facial mucosa and loss of inter-dental papillae [10, 11] which in

turn produces a longer restoration that may not look esthetic. However, there are many factors that affect the way the soft tissue responds to implant placement such as the periodontal form, the biologic width, the depth of the implant, etc. [9, 12, 13].

Many studies have been performed with the aim of optimizing the esthetic outcome of implants. As a result, implants are now placed immediately after extraction of anterior teeth to minimize bone and soft tissue loss and they are placed with particular attention to the definitive positioning of the gingival margin. Also, the use of immediate provisilization has helped in contouring the gingival tissue and inter-dental papilla to achieve the desired esthetic result [3, 9, 12, 13].

Another factor that affects the inter-dental bone is the distance between the implant and adjacent teeth. According to Tarnow the mesiodistal distance between an implant and an adjacent tooth should be at least 2mm to maintain the inter-dental bone and 3mm between adjacent implants [14]. Maintaining this distance is not always easy since the implants currently on the market are cylindrical in shape while the anterior teeth they replace have an elliptical /oval or triangular cross sectional form. Therefore, cylindrical implants may occupy a wider mesio-distal dimension than the tooth being replaced, reducing the amount of bone present between the implant and the adjacent teeth. Further, because of the elliptical shape of teeth, immediate implant placement following extraction often produces a faciolingual space between the implant and the surrounding bone crest.

A third factor that affects the loss of inter-dental bone is the pattern of bone loss that occurs around implants during the bone-healing phase. Bone loss around implants usually proceeds past the smooth collar of an implant and stabilizes at the level of the first thread.

Multiple implant companies have realized that recently and currently offer implants that have a rough surface to the platform level.

CHAPTER TWO

AIM OF THE STUDY & IMPLANT DESIGN

Aim of the Study

The aim of this study is to test the effect of a new two piece experimental implant design refered to in this study as the experimental implant with an HA coated inter-proximal surface on bone to implant contact % (BIC %) and on bone apposition / retention along the second piece compared to an HA coated commercially available root form implant.

Implant Design

The experimental experimental implant is a two piece implant that functions as a single unit. The apical part has the form of a conventional screw type root form implant while the coronal part has an epileptical shape to resemble the coronal shape of the anterior tooth it is replacing. The coronal part has an inter-proximal platform that mimics the cemento-enamal junction and which is coated with HA [4, 15, 16, 17, 18]. The 2 parts are held in place by a Morse Taper male-female type of lock during the bone-healing period after which they will both be osseointegrated to the surrounding bone (figures 1, 2, 3).

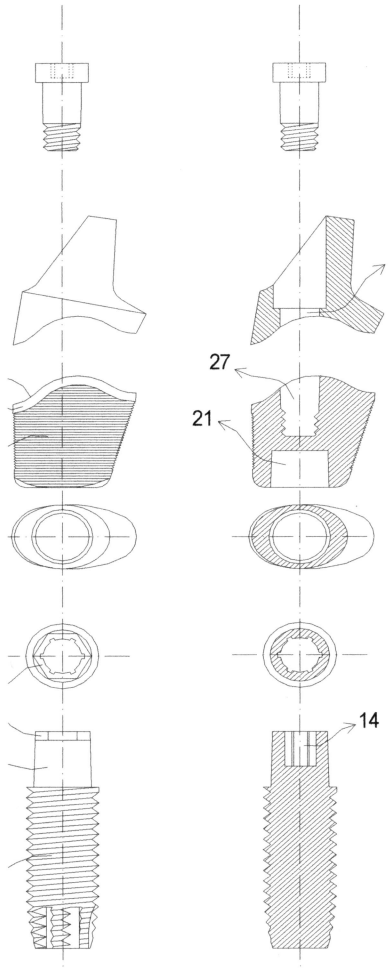


Figure 1. Experimental Implant Design

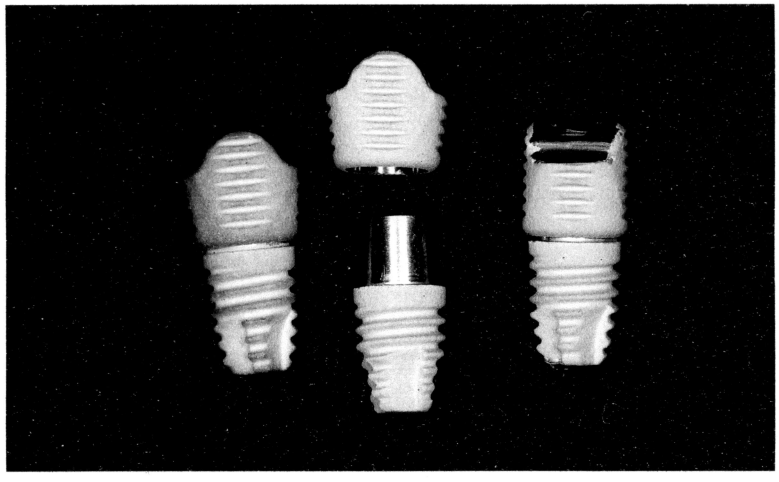


Figure 2. Experimental Implant Parts

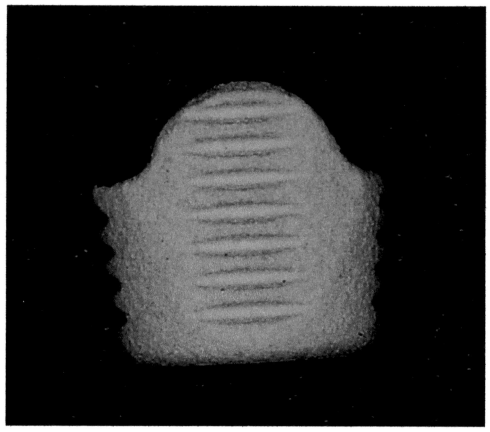


Figure 3. Coronal Part of Experimental Implant

This new Experimental Implant design has potentially the following advantages:

1. More initial bone-to-implant contact in the coronal part of a tooth socket following immediate implant placement.

2. Because of the elliptical platform of the coronal part of the implant, the mesio-distal space between implants and between implants and teeth should be wider than that distance occupied by a traditional circular platform, possibly preserving bone inter-proximally (figure 4).

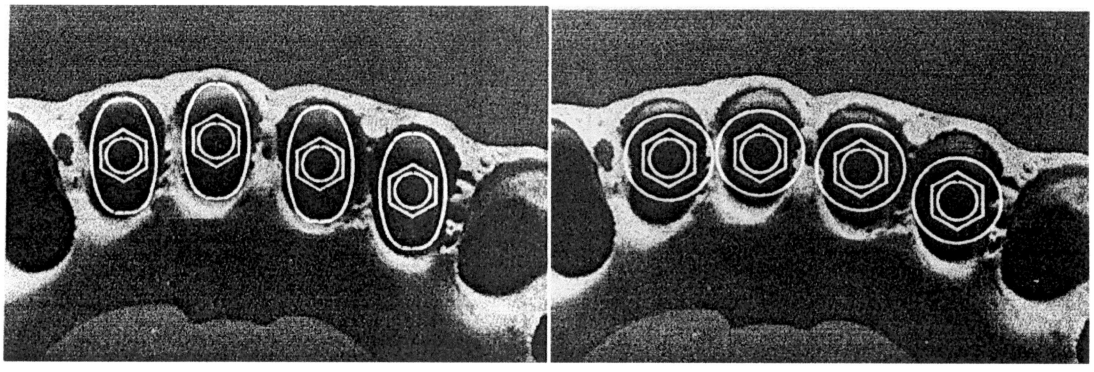


Figure 4. Mesio-distal space between implants, elliptical vs circular.

3. Because of the availability of the coronal part of the experimental implant in both straight and angled configurations, a better emergence experimental may be achieved even if the implant is miss-positioned (to a certain extent).

4. The HA inter-proximal surface treatment and scalloped coronal platform may mimic a cemento-enamal junction and allow growth of inter-proximal bone, thereby regenerating papilla or sustaining the presence of an existing papilla.

In this study the bone to implant contact percentage (BIC%) was evaluated and compared to a commercially available HA coated implant. Also the possibility of bone apposition / retention beyond the existing bone level was evaluated. The effect of the presence of a junction between part one and part two of the experimental implant on bone apposition was also be noted.

The experimental prototype implants were manufactured by B&W Argentina SRL. The implants were 9.0mm in length with the threaded area of the first part measuring 5.0mm and the second elliptical scalloped part measuring 4.0mm. The scallop was 2.0 high.

CHAPTER THREE

MATERIALS & METHODS

Site

The study was performed in Loma Linda University under the control of the Center of Implant Dentistry and the Animal Care Facility of the university.

Animals

Ten male white New Zealand rabbits [19, 20, 21, 22, 23] were used for the study. The animals were housed and taken care of at the animal care facility at Loma Linda University.

Implant placement

The surgeries were conducted in the animal care facility at Loma Linda University after being approved by the animal care committee of the university. Animals were sedated with Rompun (Xylazine) via an intramuscular injection (5mg/kg of body weight) followed by Ketalar (Ketamine) intramuscular injection (35mg/kg of body weight). As soon as the animals were sedated, the right and left tibial areas were shaved, disinfected with betadine and local anesthetic (xylocaine 2%+1:100,000 epinephrine) was infiltrated at the surgical site. A 4.0cm incision was made near the flat portion of the right and left tibial heads near the medial joint. Full thickness flap was elevated and one

osteotomy (3.25mm in diameter and 8 mm in length) was drilled in each tibia using saline irrigation also bleeding osteotomies were created (figures 5, 6, 7, 8).

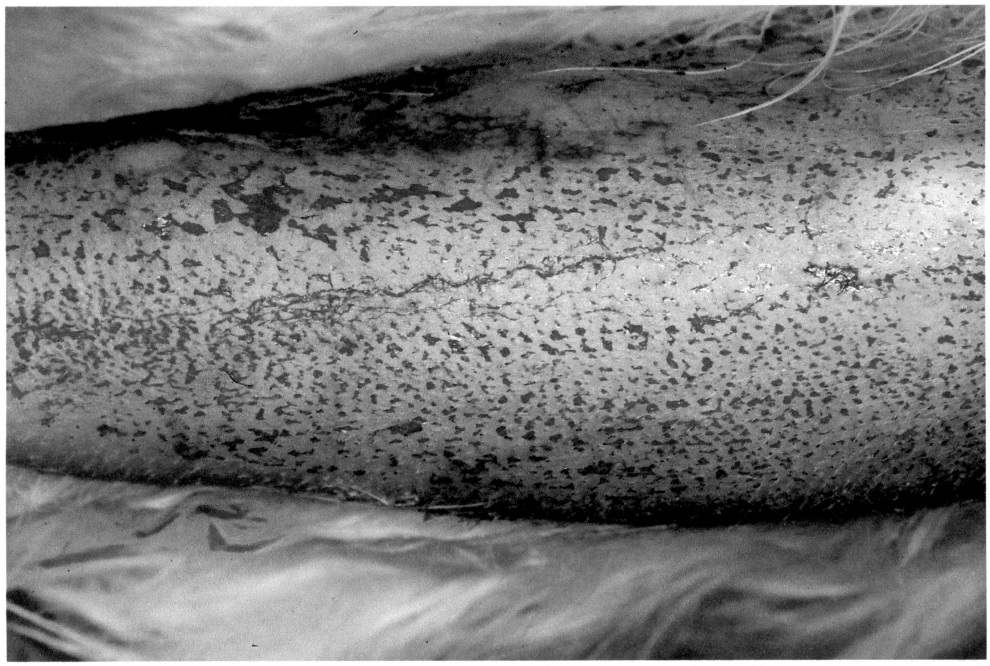


Figure 5. The tibial area shaved and disinfected with betadine.

Figure 6. Incision exposing tibial head.

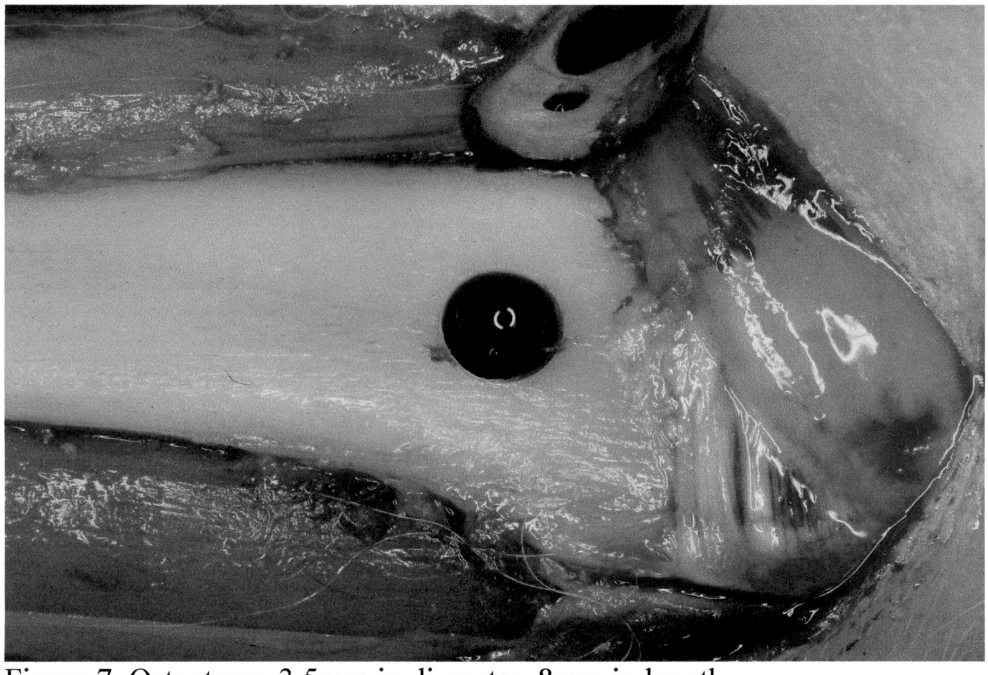


Figure 7. Osteotomy 3.5mm in diameter, 8mm in length.

Figure 8. Bleeding osteotomies.

Each osteotomy then received either a experimental implant or a standard implant; the implant placed was chosen randomly. After the osteotomy preparation the animals were divided in to two groups with the difference being the level of the scalloped second part of the experimental implant in relation to the existing bone level as shown (figures 9, 10).

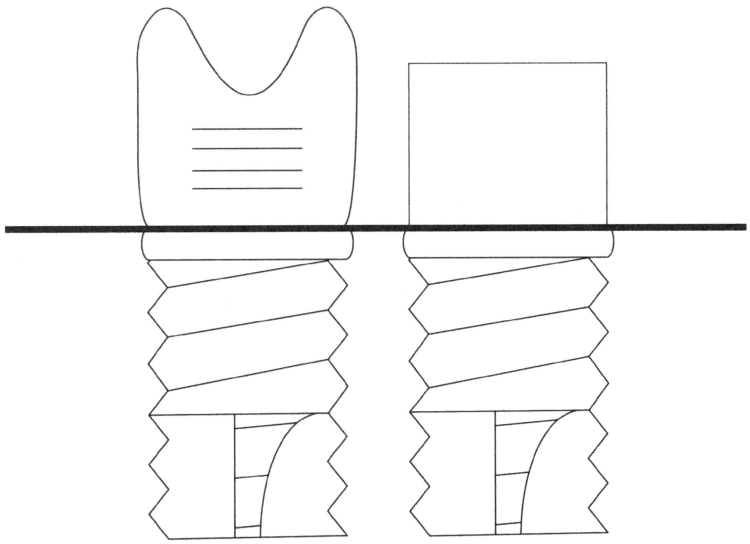


Figure 9. Group one (the solid black line represents the existing bone level).

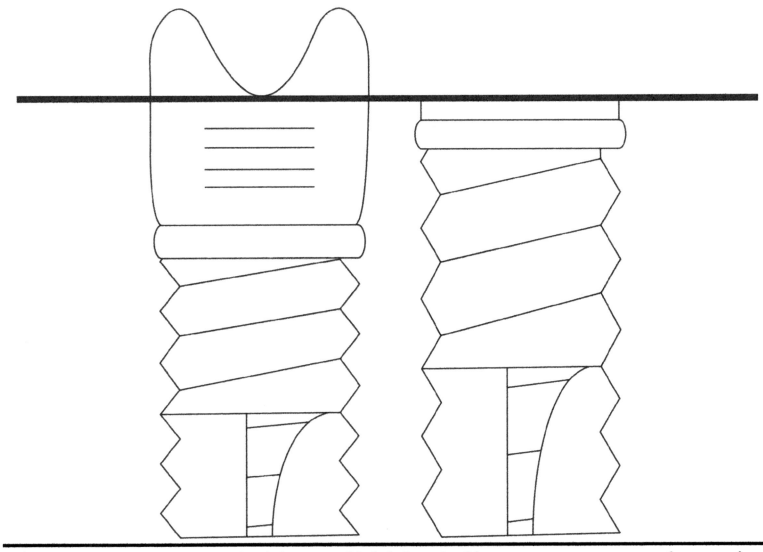


Figure 10. Group 2 (the solid black line represents the existing bone level).

Group One

Group one consisted of 6 animals. In this group the experimental implant was placed with the junction between the first part and the second part at the bone crestal level; thus the second scalloped part on the experimental implant was totally exposed extending 4.0mm over the crest of the ridge (figures 11,12, 13).

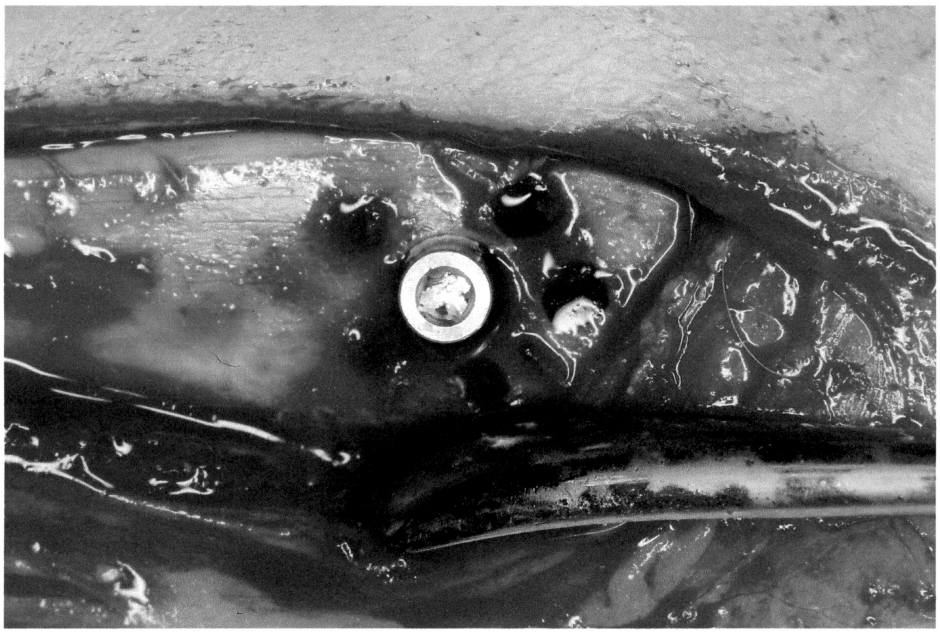


Figure11. Part one of the experimental implant placed.

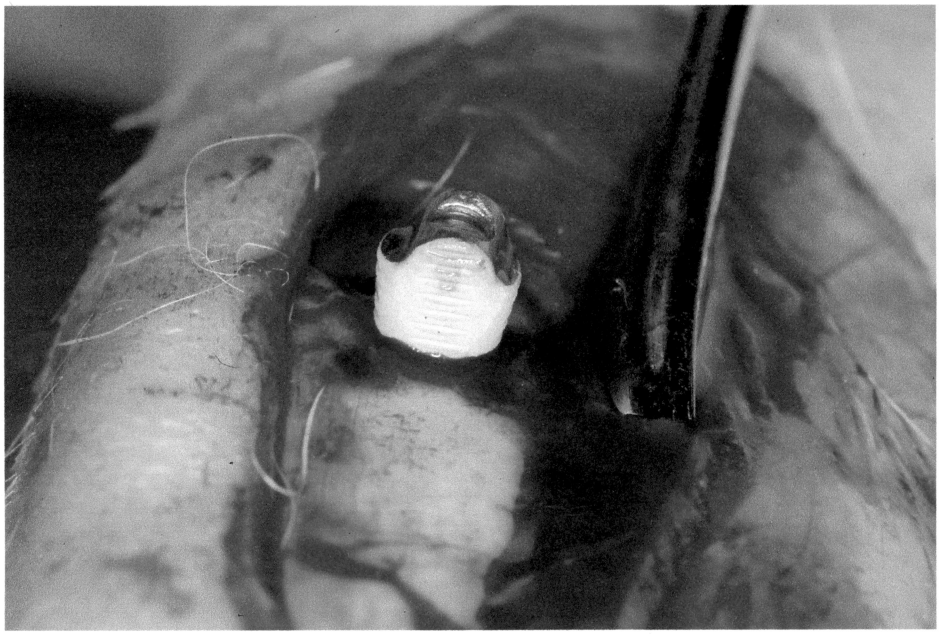


Figure 12. Part two of the experimental implant placed

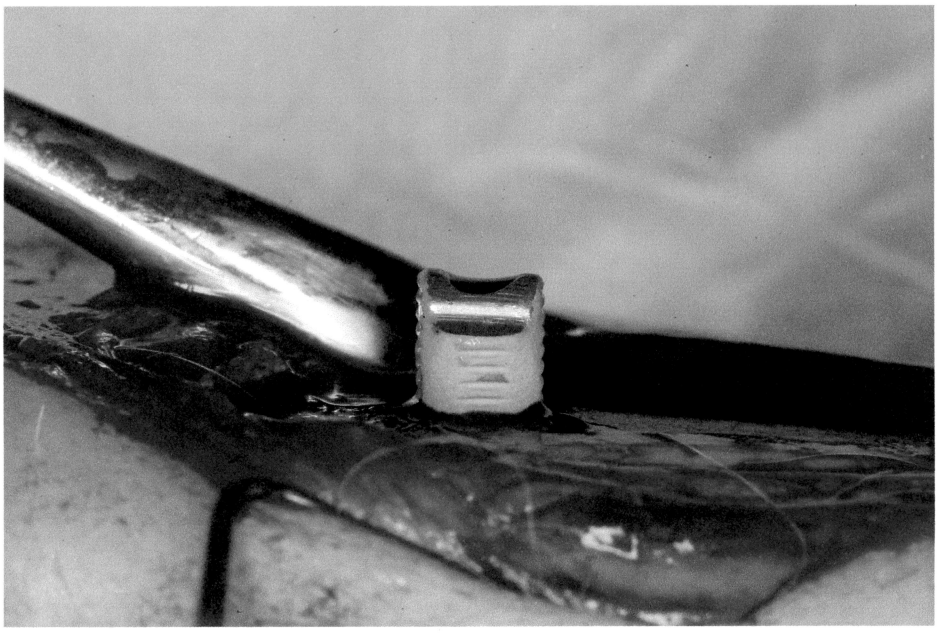


Figure 13. Part two of the experimental implant placed

In the control group the osteotomy received one threaded root form implant 8mm in length and 3.5mm in diameter. The implant was placed flush with the bone and a smooth 3mm long healing abutment was screwed to it (figures 14, 15).

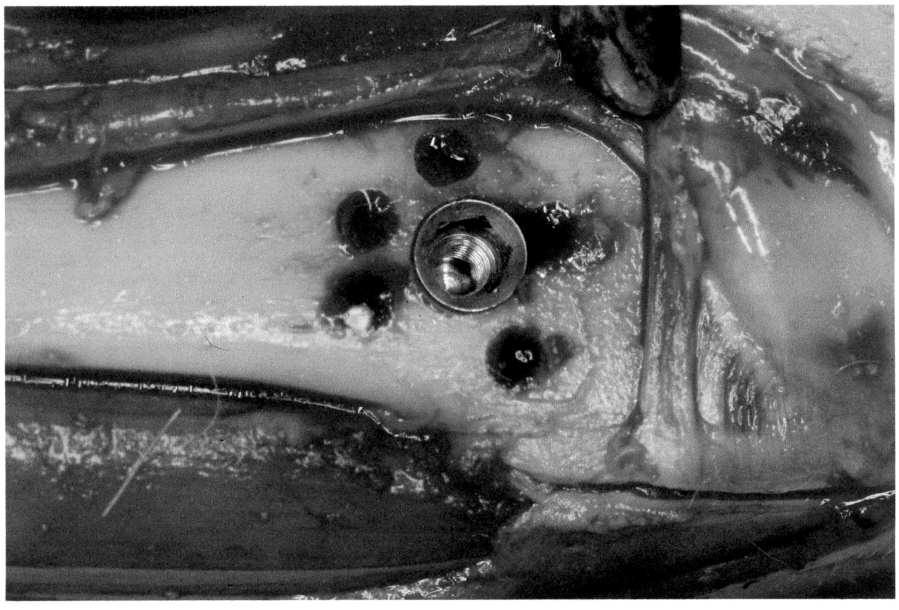


Figure 14. Control implant placed flush with bone.

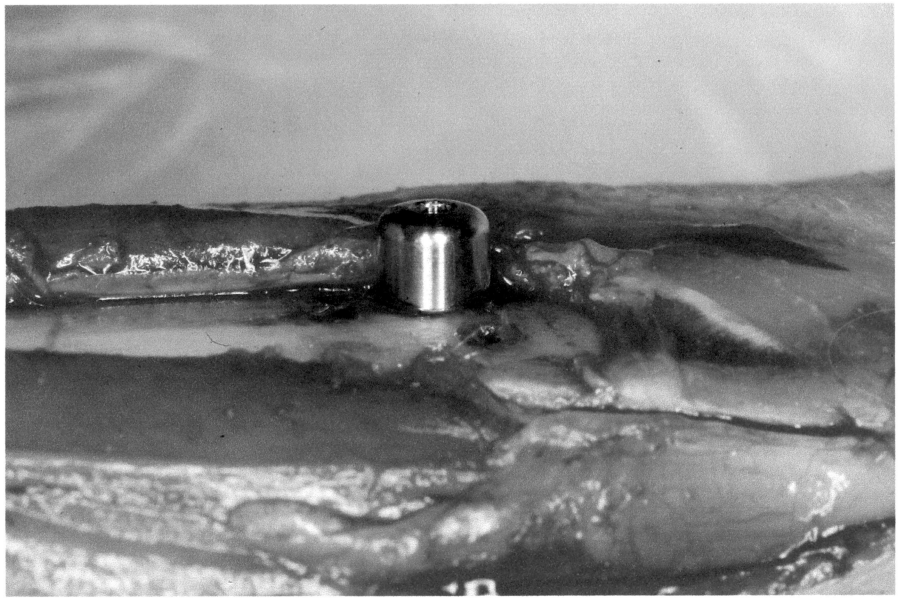


Figure 15. 3mm healing abutment attached to control implant.

Following this process, the muscular fascia and skin were sutured with an interrupted resorbable chromic gut suture. (figures 16, 17).

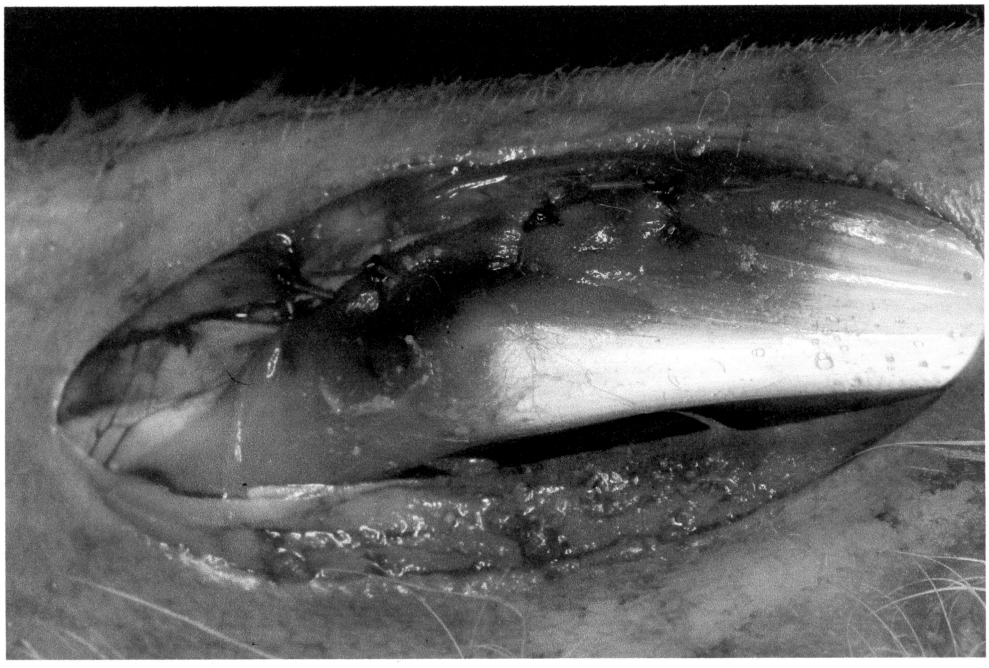


Figure 16. Muscular fascia sutured.

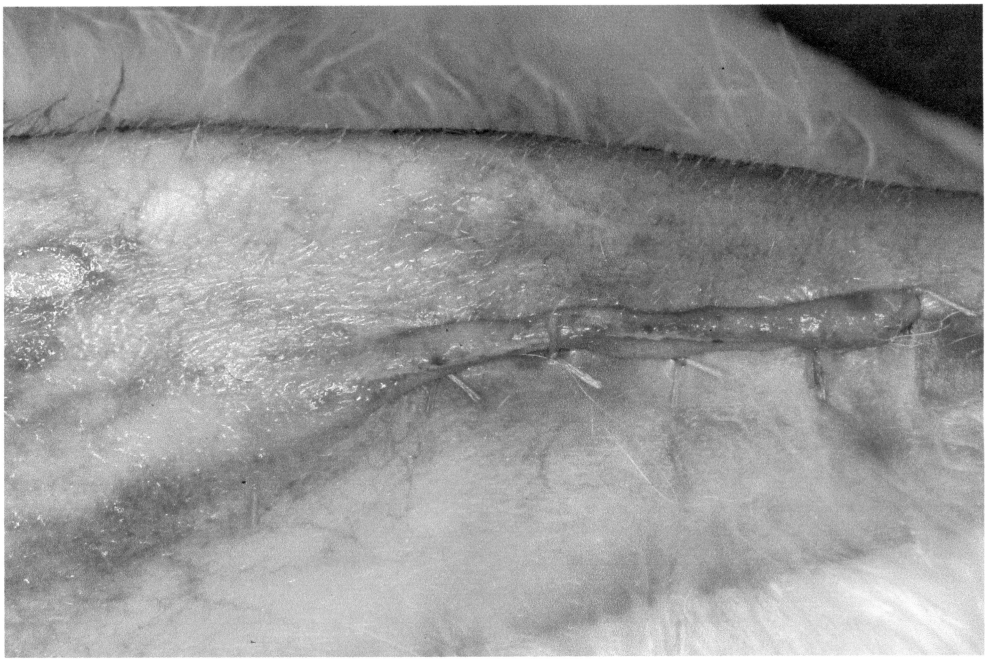


Figure 17. Skin sutured.

A total of 6 experimental test implants and 6 root form control implants were placed in 6 rabbits.

Group Two

Group two consisted of 4 animals. The site preparation, incision and osteotomies were prepared in the same manner described in group one (figures 5, 6, 7, 8) . In this group the test sites received the experimental implant in a way were the junction between part one and part two will be 2mm below the bone surface thus leaving 2mm of the scalloped part exposed above the crest of the ridge (figures 18, 19)

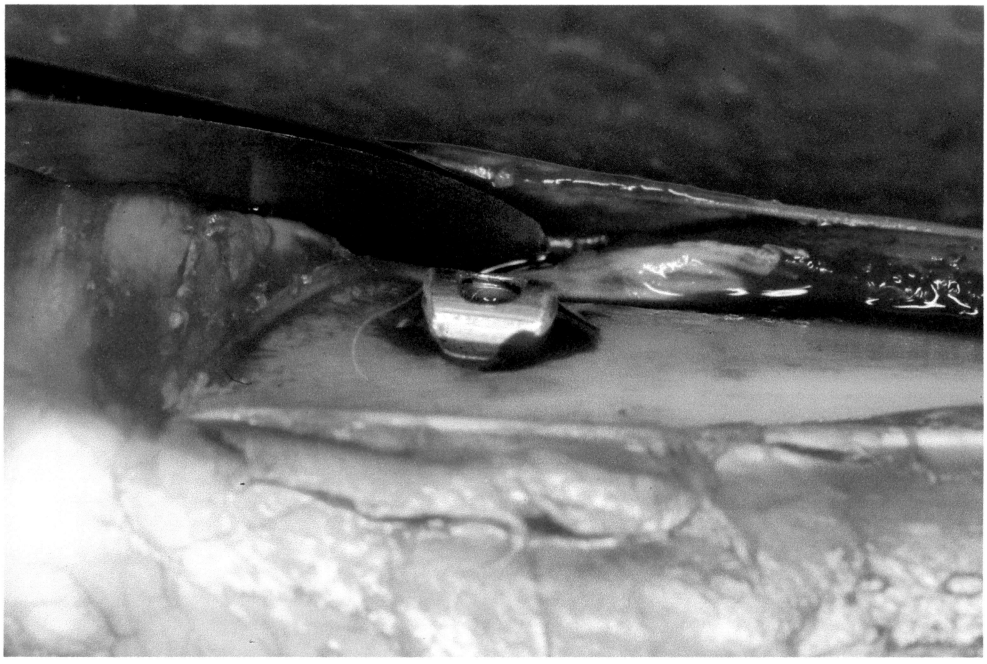


Figure 18. Side view of experimental implant placed in group 2.

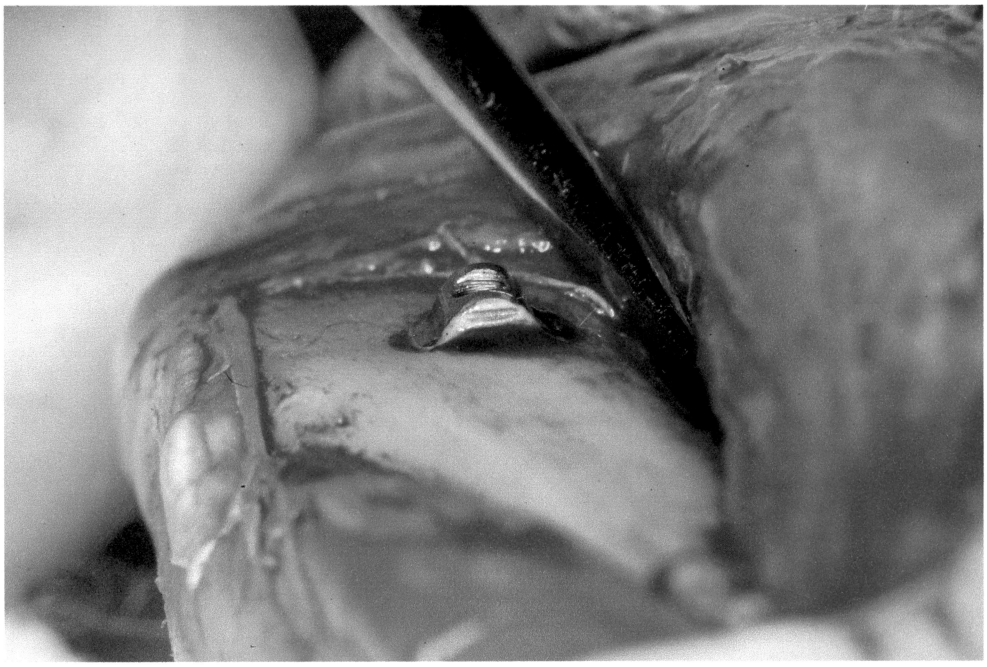


Figure 19. Side view of the scalloped part in place 2mm above bone in group 2.

The control implants for this group were standard root form implants 8mm long and 3.5mm in diameter placed at the level of the crest of the ridge and a cover screw placed instead of the 3.0mm healing abutment (figure 20).

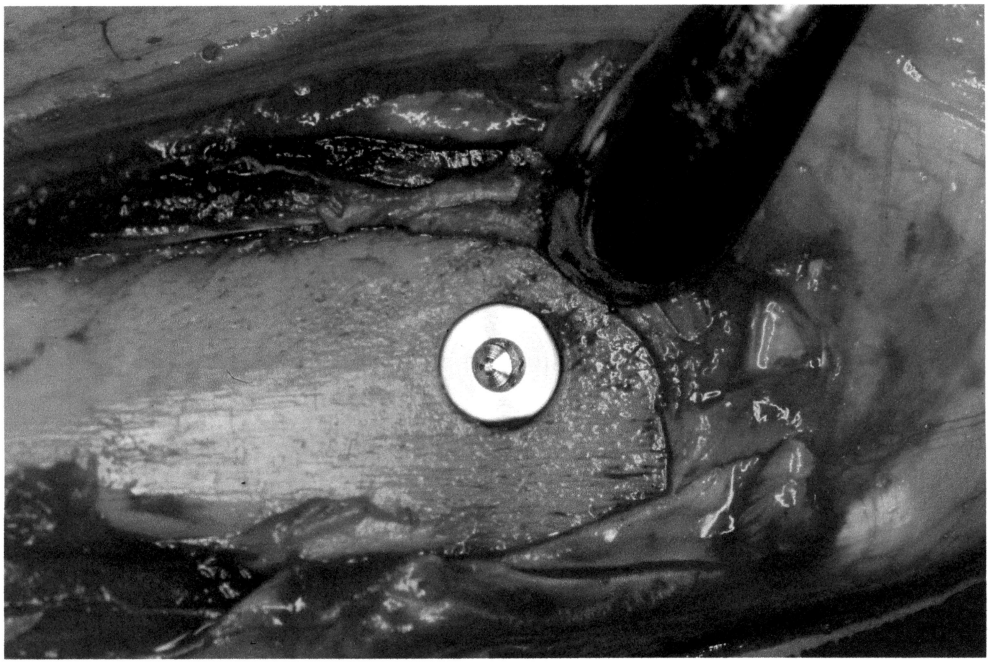


Figure 20. Control implant with cover screw at bone level in group two.

Following this process, the muscular fascia and the skin were sutured with an interrupted resorbable chromic gut 5.0 suture an vicryl 5.0 (figures 16, 17). A total of 4 experimental implants and 4 root form control implants were placed in 4 rabbits. Following the implant placement, the surgical wounds were cleaned once daily for 10 days with Lepecid BR spray. Also Burenorphine (cl.V narcotic) was given in the dose of 0 .025mg/kg every 12hrs for 1 day for pain control. The animals were sacrificed after 27 days which is half the sigma period (time for complete bone turnover) [21, 24] by administering a cardiac overdose of Barbiturate.

Sample Collection

After sacrificing the rabbits, a gross specimen was collected in the following manner:

1. Incisions were made at the previous surgical sites.
2. Full thickness flaps were raised.
3. Test and control implant sites were identified.
4. A gross bone specimen that includes the test or control implant along with a minimum of 20.00 mm on each side of native bone was collected using a bone saw (figures 21, 22).
5. The specimens were placed in 10% buffered formalin, labeled and transported to the laboratory for processing.
6. A total of 20 specimens were collected

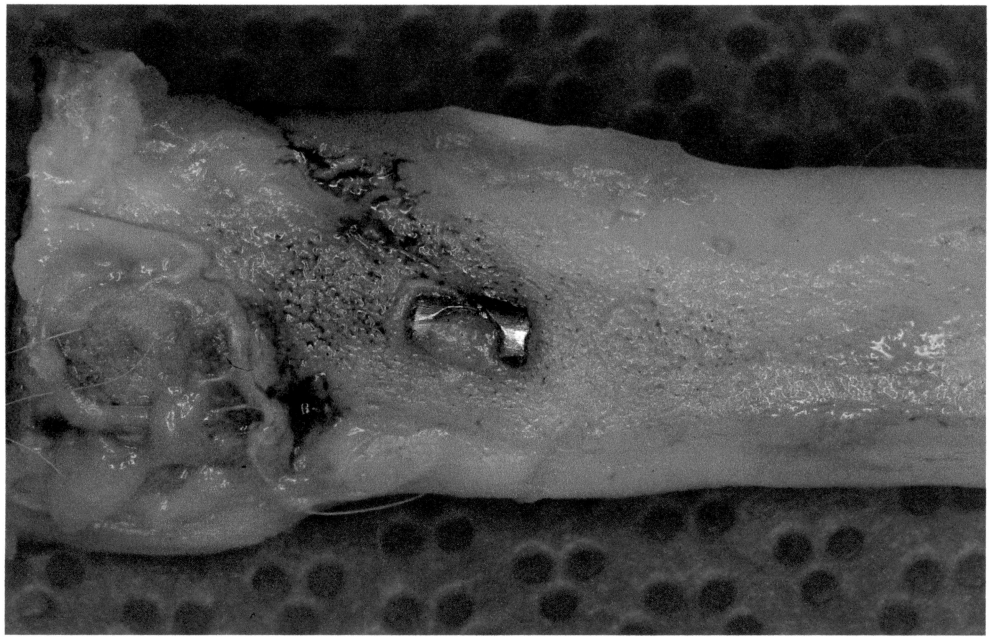


Figure 21. Gross sample collection with surrounding bone.

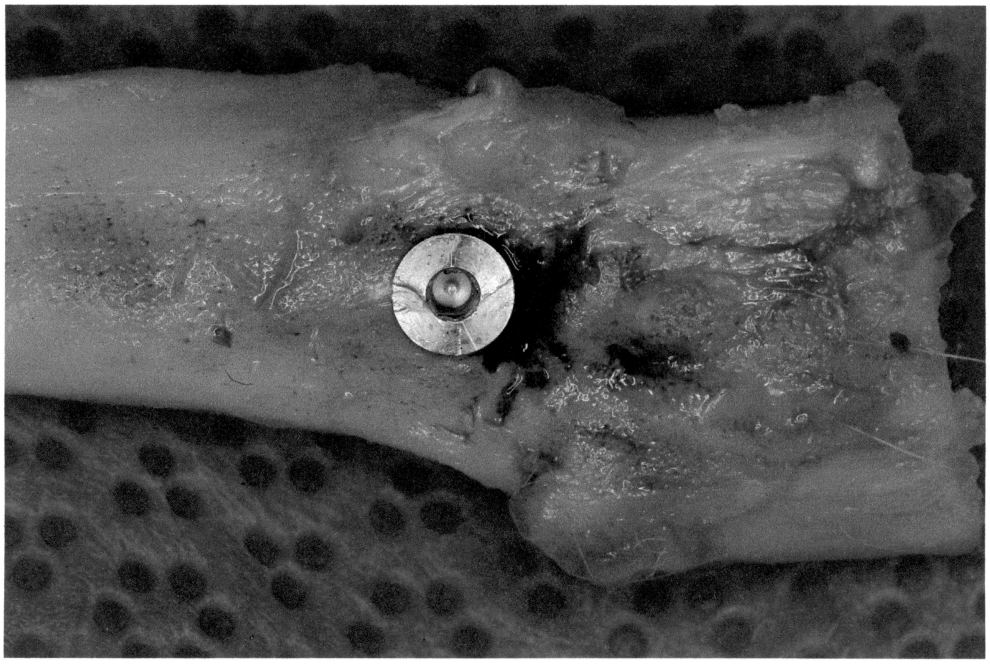


Figure 22. Gross sample collection with surrounding bone.

Histologic Preparation

At the Hard Tissue Research Laboratory the specimens were dehydrated with a graded series of alcohols for approximately 14 days. Following dehydration, the specimens were infiltrated with a light-polymerized embedding resin (Technovit 7200 VLC). Following approximately 14 days of infiltration with constant shaking at normal atmospheric pressure, the specimens were embedded and polymerized by 450-nm light, with the temperature of the specimens never exceeding 40°C. The specimens were then prepared by the Exact cutting/grinding technique [25, 26]. The specimens were cut to a thickness of 150μm on an Exact cutting/grinding system (Exakt Apparatebau, Oklahoma City, OK.) Following this, the sides were polished to a thickness of 35 to 45μm using the Exact microgrinding system, and they were stained with Stevenel's blue and van Gieson's picric fuchsin. The specimens were analyzed using NIH Image, an image analysis software program developed by the National Institutes of Health on a Power Macintosh.

After the images were prepared, bone – implant contact percentage (BIC %) was measured as the percentage of the length of the mineralized bone tissue in direct contact with the implant surface out of the designated total length of the implant surface. Two groups of BIC % measurements were done for each specimen:

1. BIC % was measured from the top of implant to the inferior border of the superior cortical plate.
2. BIC % was measured over the total length of the implant.

Statistical Analysis

The Wilcoxon – Mann – Whitney – rank sum test was used to make the statistical comparison of the BIC % between the test and control implants in each group.

CHAPTER FOUR

RESULTS

A total of 10 rabbits were operated on. 10 experimental implants and 10 control implants were placed one in each rabbit tibia. Group 1 consisted of 6 rabbits (6 experimental implants and 6 control implants). Group 2 consisted of 4 rabbits (4 experimental implants and 4 control implants). All ten rabbits and all 20 implants were included in the analysis. With the exception of one rabbit that had a decreased apatite during the first 48 hrs post surgical, healing was uneventful.

Clinical Results

The previous surgical entry site was easily identifiable from the scared incision line (figure 23) of the previous surgery.

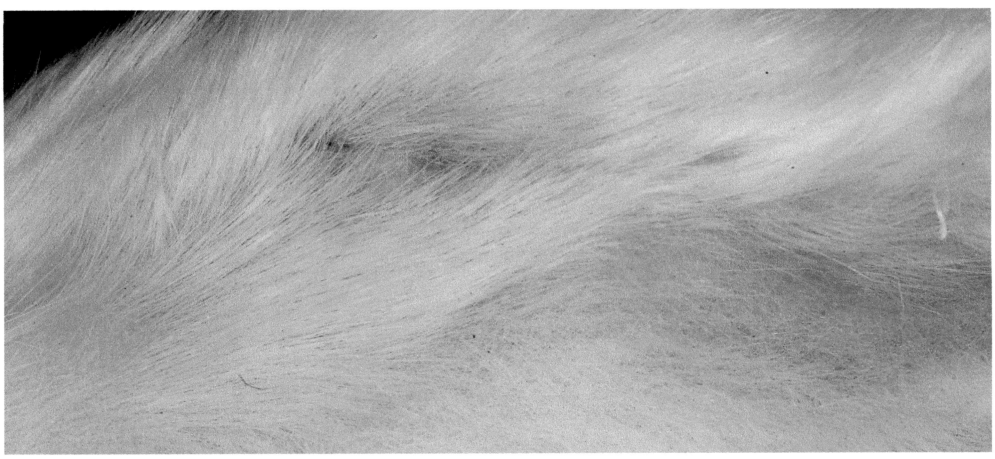


Figure 23. Previous incision site

Upon re-opining the previous surgical sites to collect the samples for histology the following was noticed: All implants seemed to be clinically stable with no mobility in both group one and two.

Group One

Implants were covered with tissue that varied from being soft and fibrous (figures 24, 29) to hard and bony (figures 25, 26, 27, 28, 30, 31). The amount of hard tissue coverage varied between samples, and samples from the experimental implants and control implants seemed to be inconsistent. It was also noticed that the muscle fascia had collapsed around some of the implants preventing bone formation.

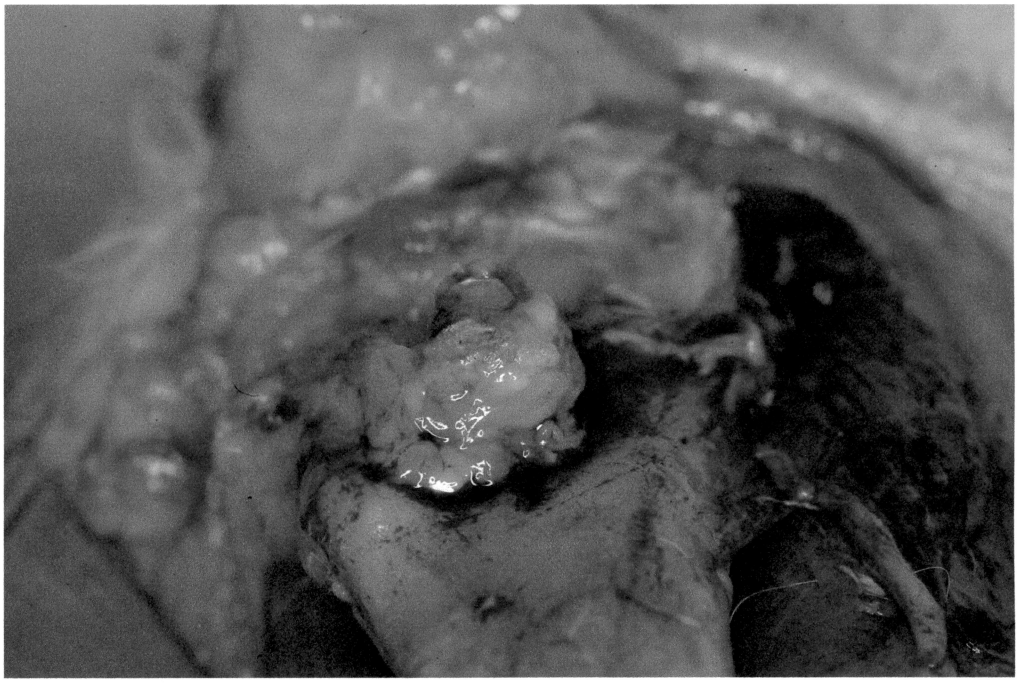


Figure 24. Experimental implant sample with soft tissue around the implant's 2nd part.

Figure 25. Hard tissue formation around the experimental implant 2nd part

Figure 26. Hard tissue formation around the experimental implant 2nd part

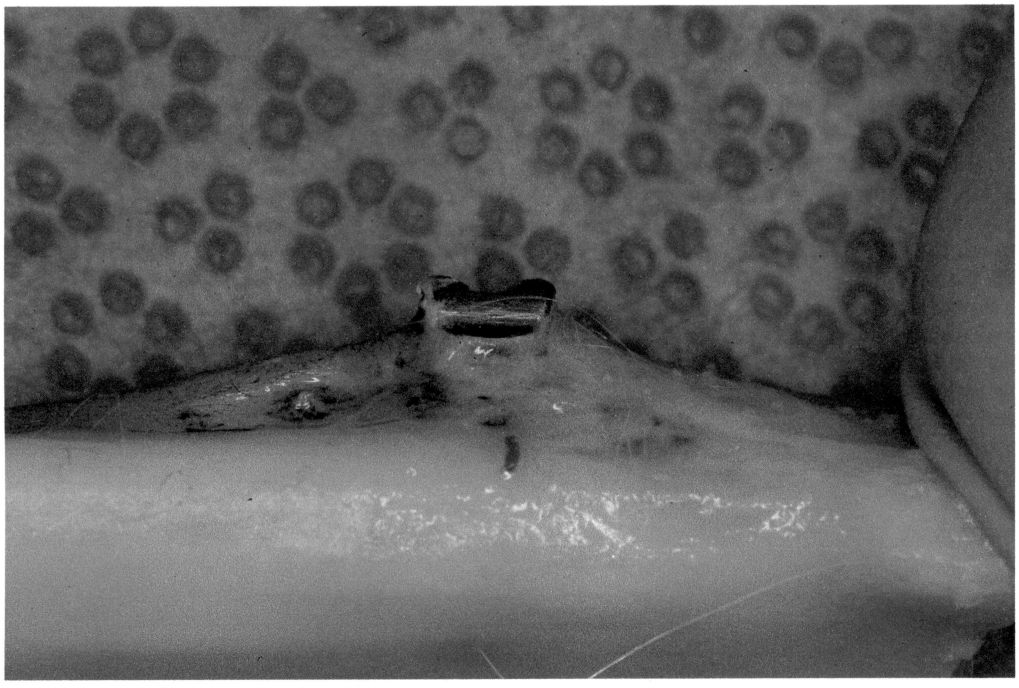


Figure 27. hard tissue formation around the experimental implant 2nd part

Figure 28. Hard tissue formation around the experimental implant 2nd part

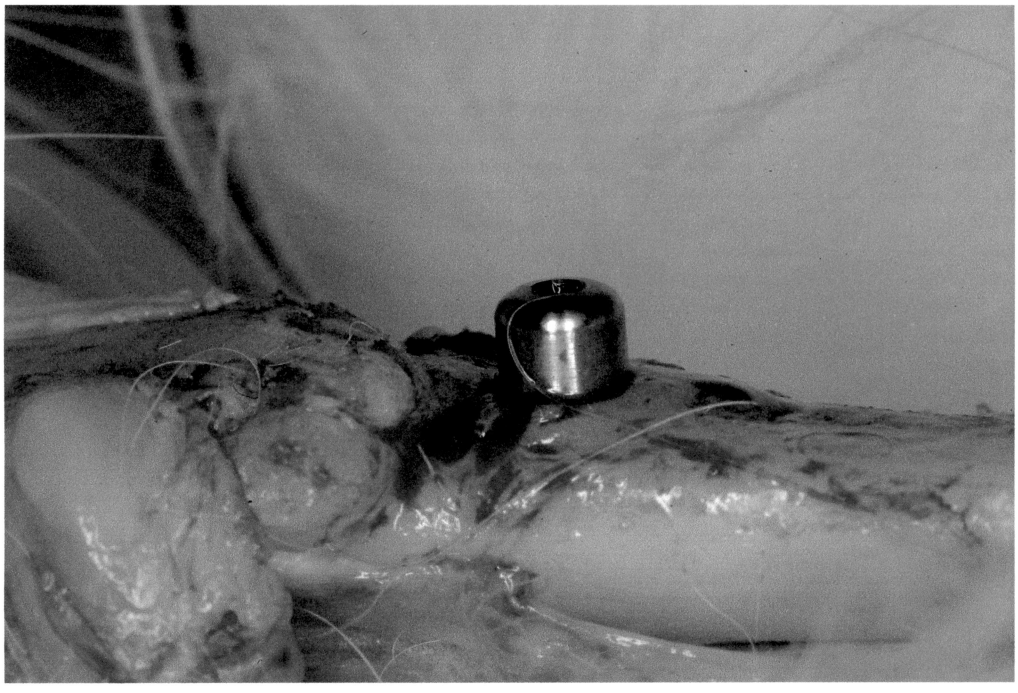


Figure 29. Control implant showing no hard tissue formation around the healing Abutment

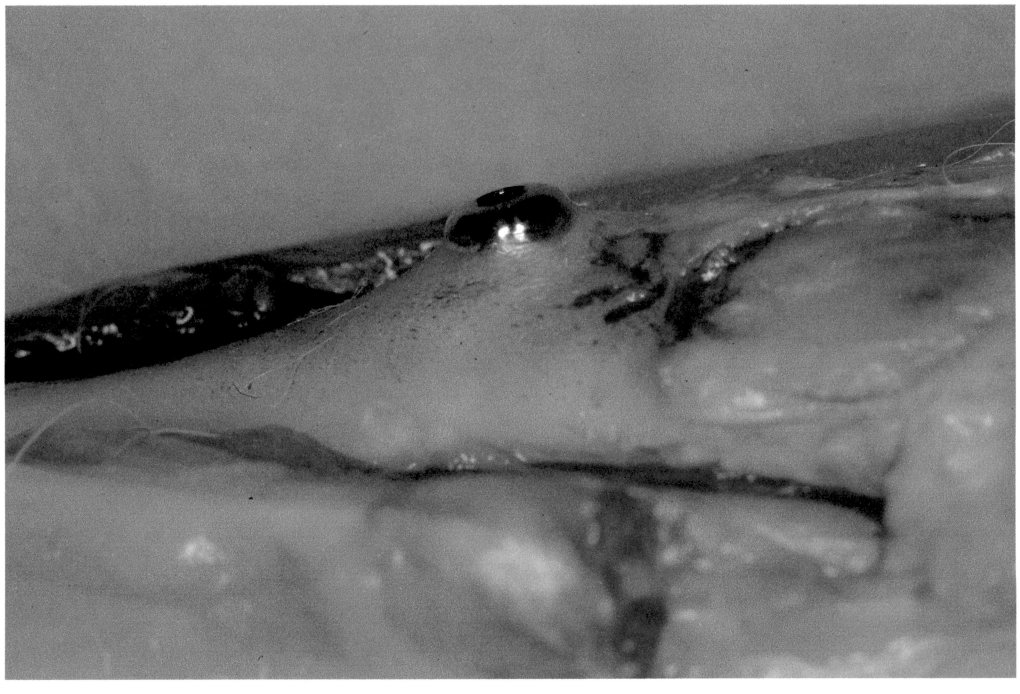


Figure 30. Control implant showing hard tissue formation around the healing abutment

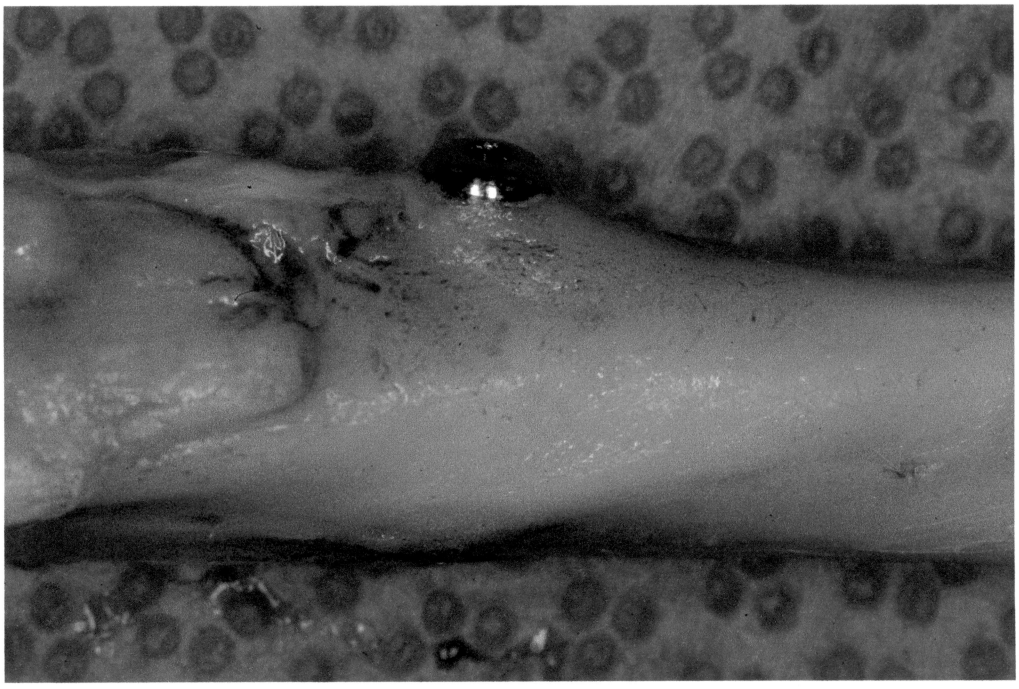
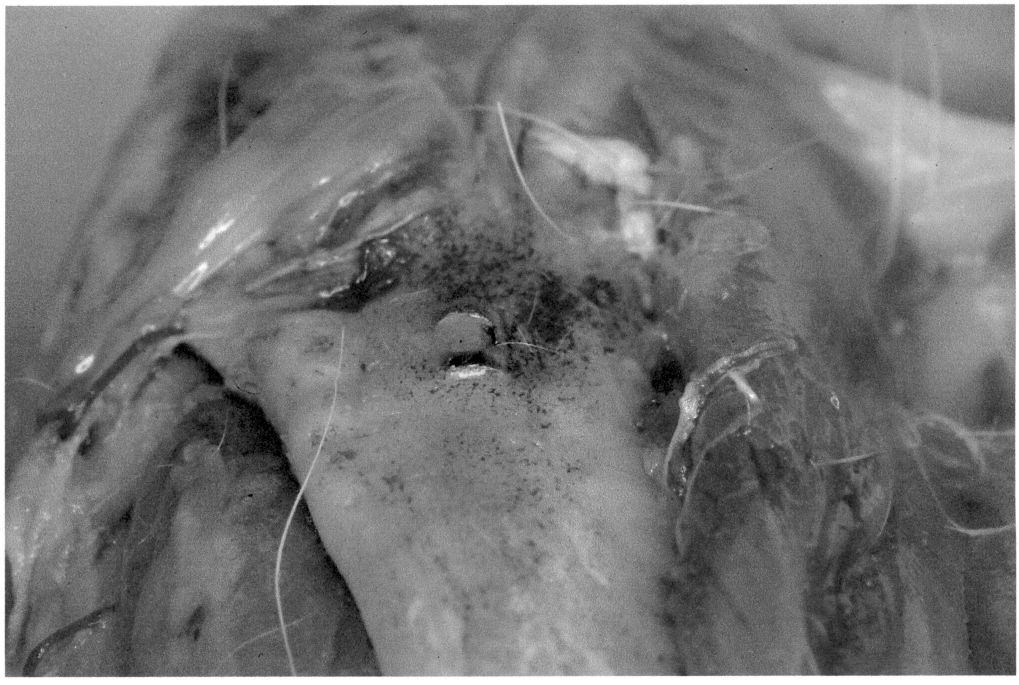


Figure 31. Control implant showing hard tissue formation around the healing abutment.

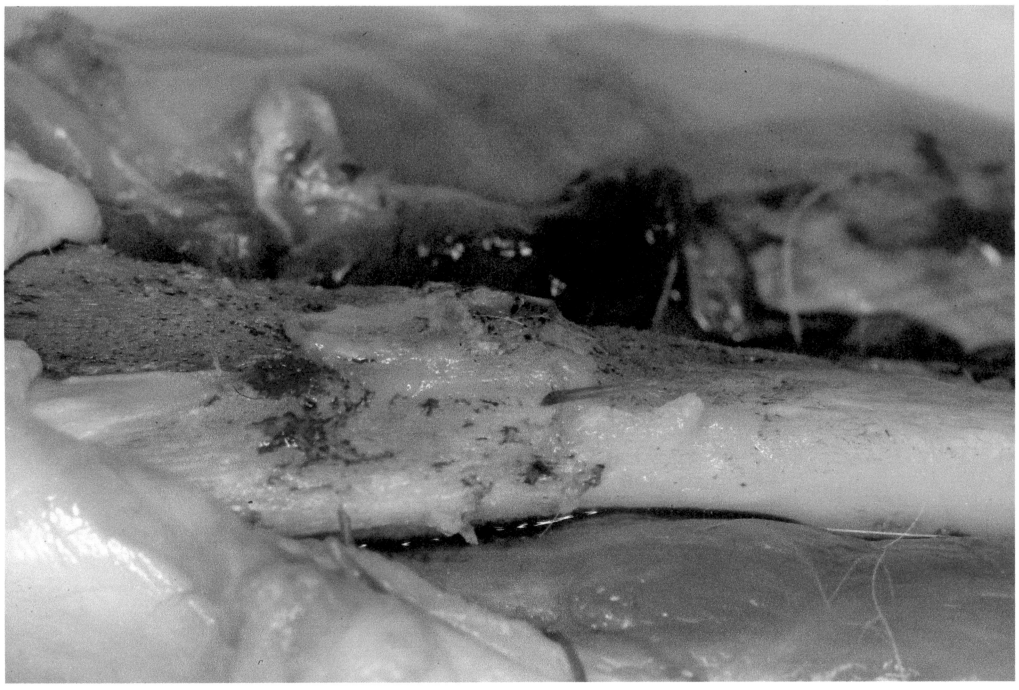
Group Two

Clinically all the experimental implant samples showed hard tissue formation along the scalloped part and partially covering the implant platform, one sample showed hard tissue covering all the platform (figures 32, 33, 34, 35). In the control implant samples the cover screw could be identified with little or no hard tissue growth on the smooth surface (figures 36, 37, 38, 39).

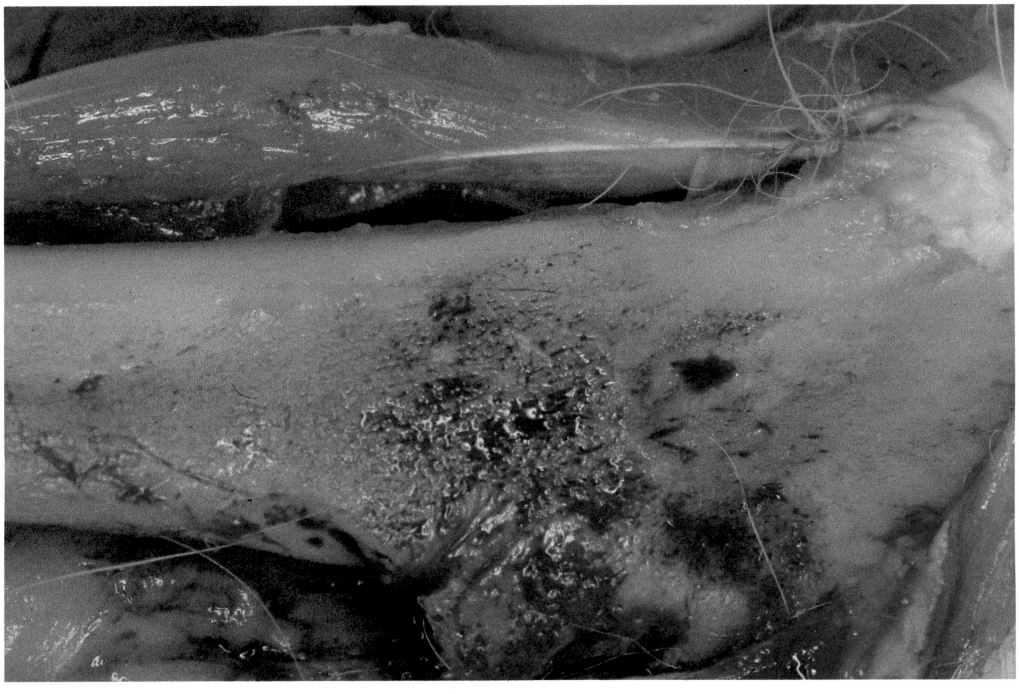
Figire 32. Group two experimental implant showing hard tissue growth over the scalloped part partially covering the platform.



Figire 33. Group two experimental implant showing hard tissue growth over the scalloped part partially covering the platform.



Figire 34. Group two experimental implant showing hard tissue growth over the scalloped part partially covering the platform.



Figire 35. Group two experimental implant showing hard tissue growth over the scalloped part completly covering the platform.

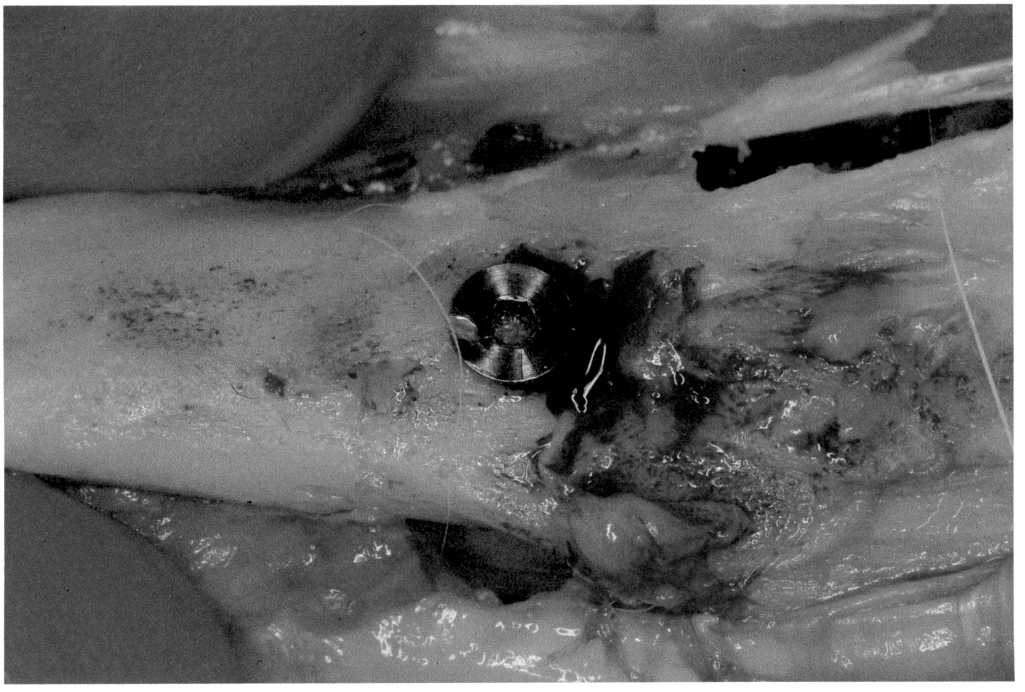


Figure 36. Group 2 control implant showing cover screw with no hard tissue growth.

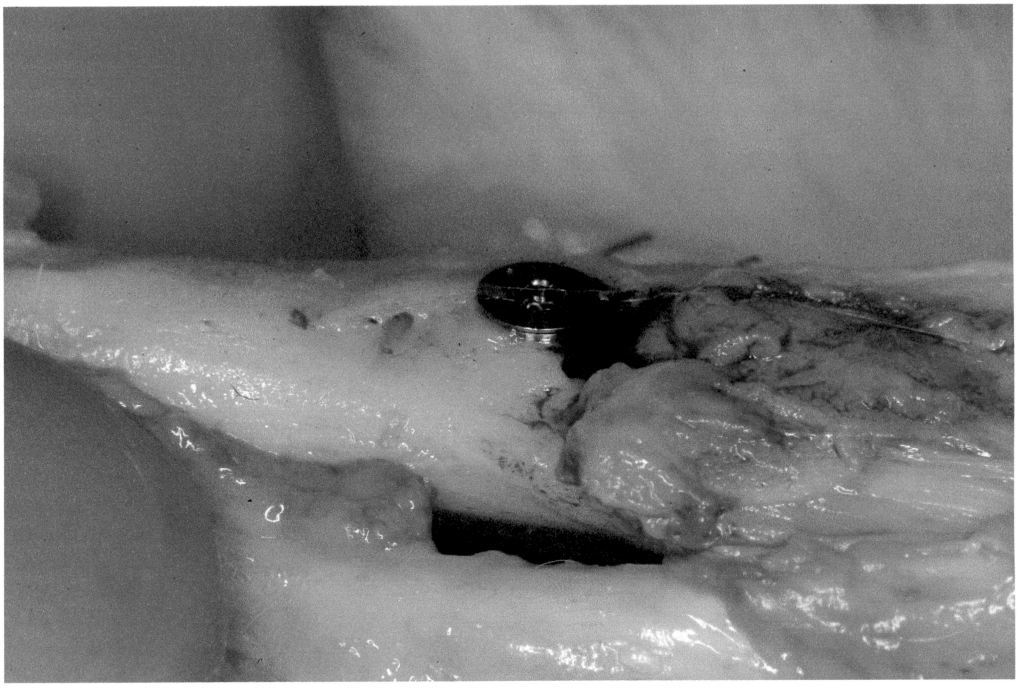


Figure 37. Group 2 control implant showing cover screw with no hard tissue growth and minimal medial bone loss.

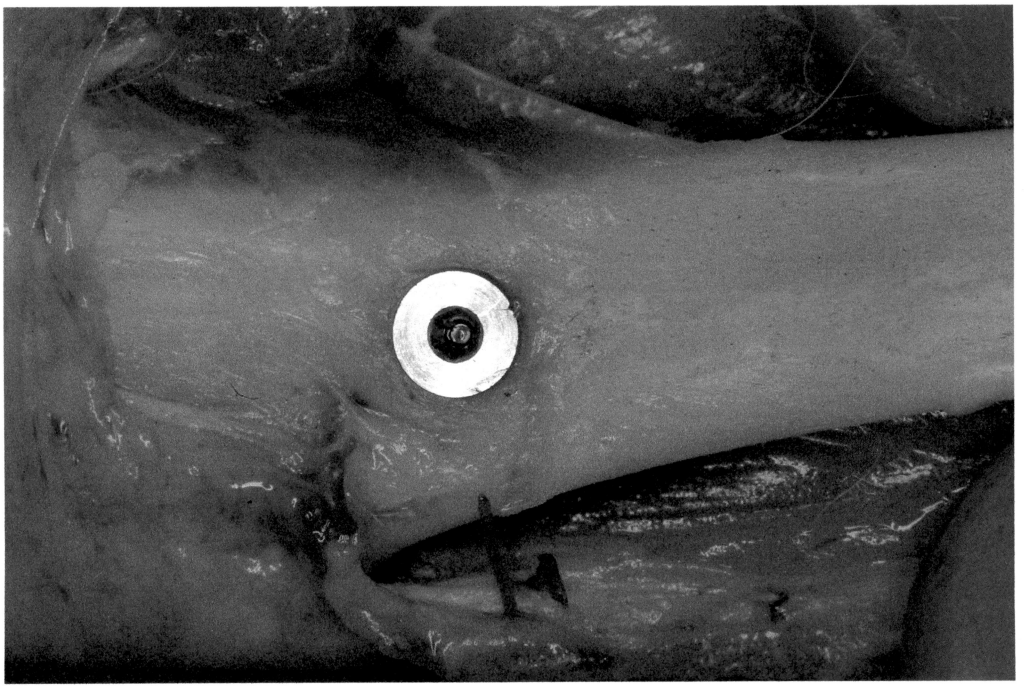


Figure 38. Group 2 control implant showing cover screw with no hard tissue growth over the cover screw.

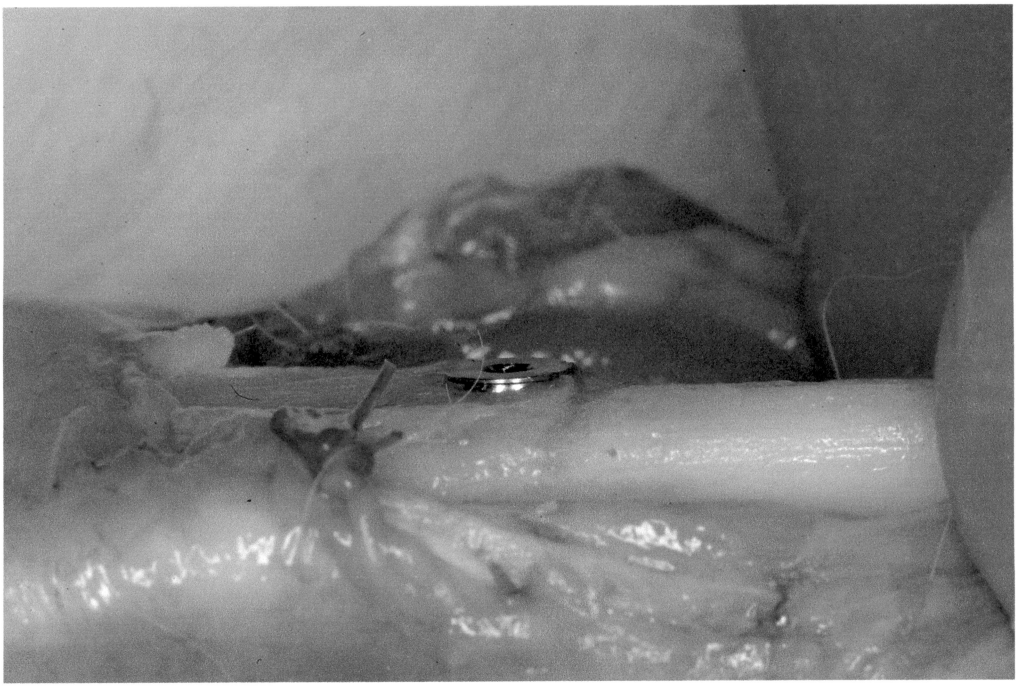


Figure 39. Group 2 control implant showing cover screw with minimal hard tissue growth

Histomorphometric Results

The histomorphometric results confirmed the clinical observations. All of the samples demonstrated bone to implant contact that varied among the different samples indicating different levels of new bone formation along the implant surface and confirming osseointegration.

Group One

New bone formation was noted above the crestal native bone in both the experimental and the control implants but varied in height and was not consistent (figures 40, 41, 42, 43). Bone formation was noted around both the HA rough treated surface and on the machined Ti surface, however it was more adapted to the HA surface (figures 44, 45). The presence of a junction in the experimental implant at the level of the native crestal bone did not seem to have an effect on supra crestal bone formation (figures 46, 47, 48).

When BIC% was measured from the top of the implant to the inferior border of the superior cortical plate, the BIC% ranged from 22.7% to 85.2 % with an average of 53.12% for the control group and from 52% to 68.5 % with an average of 60.45% for the experimental implant (table 1). Table 1 shows the BIC% from the top of the implant to inferior border of the superior cortical plate for the experimental implants and the control implants.

When BIC% was measured over the whole length of the implant, the BIC% ranged from 13.7% to 71% with an average of 44.5% for the control group and from

33.5% to 47.8% with an average of 41.4% for the experimental implant (table 2). Table 2 shows the BIC% over the whole length of the control and experimental implants.

Figure 40. Control implant showing minimal bone apposition / retention over the native crestal bone and no bone apposition on the machine surfaced part.

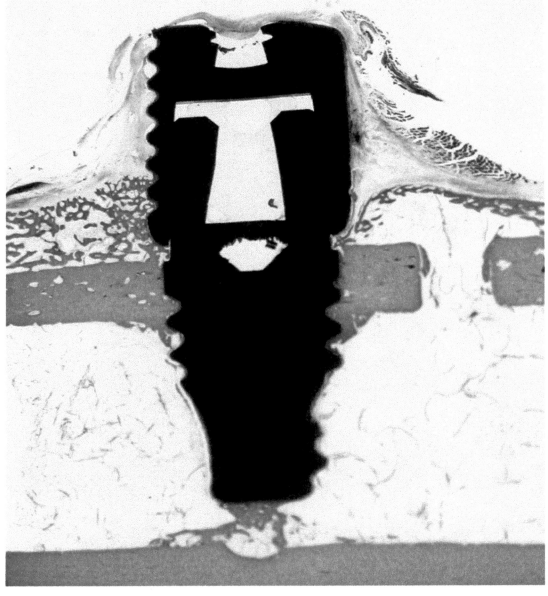


Figure 41. Porfile implant showing some bone apposition / retention over the native crestal bone and the 2nd part of the implant.

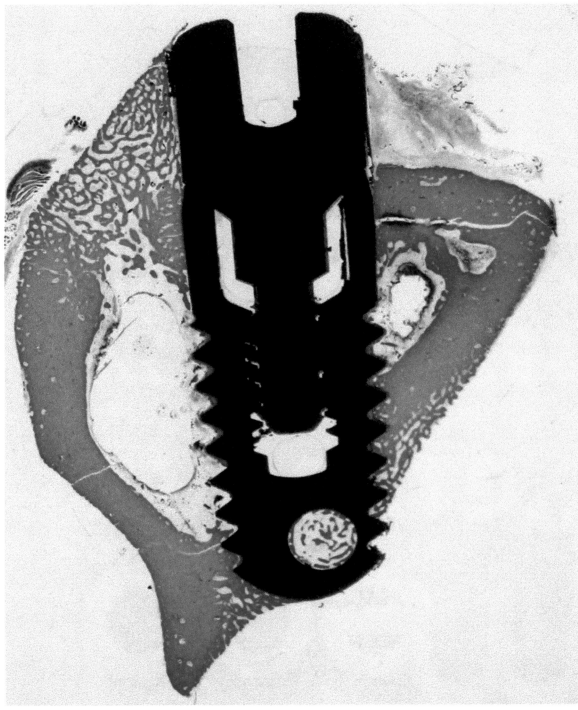


Figure 42. control implant showing bone apposition / retention over the native crestal up to the top the machine surfaced part.

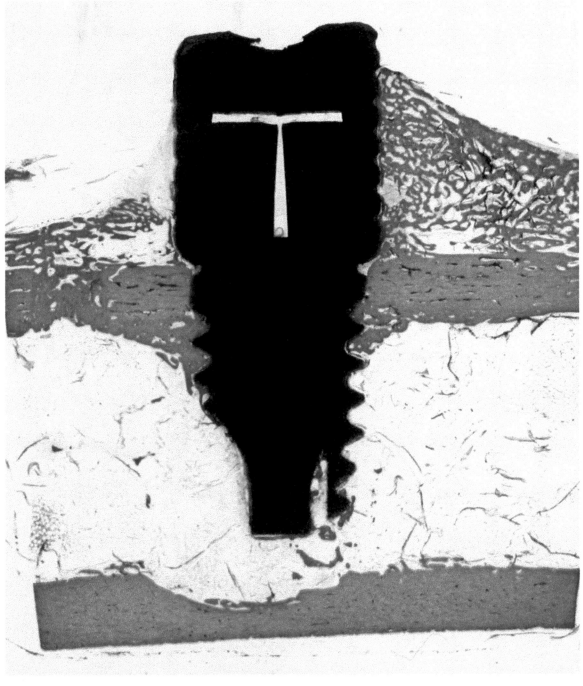


Figure 43. Porfile implant showing bone apposition / retention over the native crestal bone up to the top 2nd part of the implant .

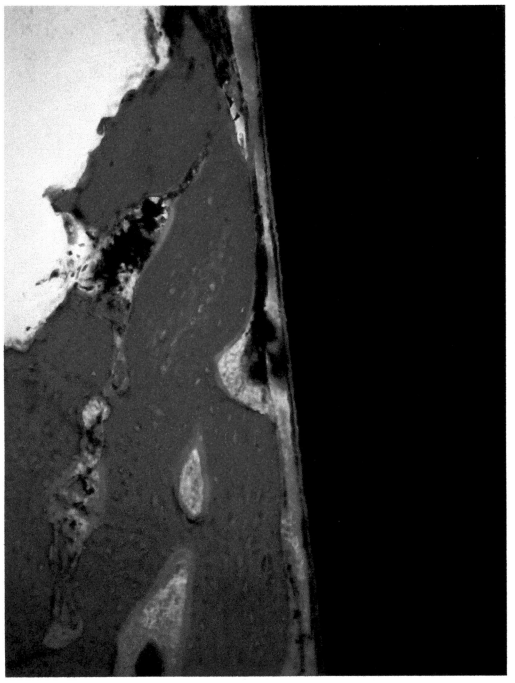


Figure 44. Bone apposition / retention along the Ti-Machined surface of the control implant (very high power slide 40X).

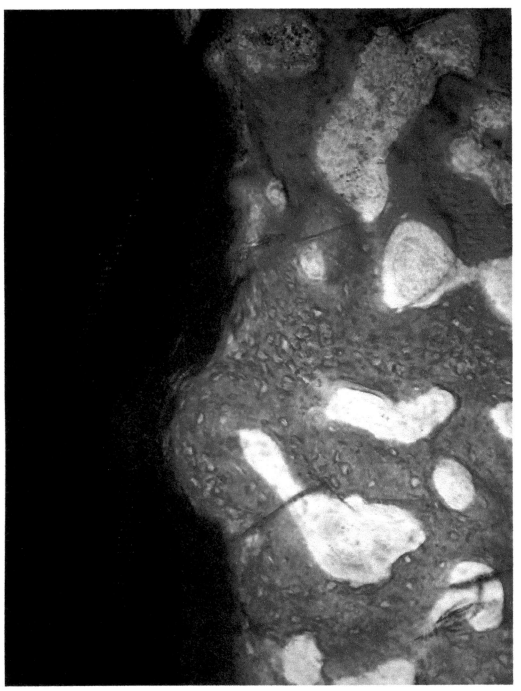


Figure 45. bone apposition / retention along the HA coated 2nd part of the experimental implant (very high power slide 40X).

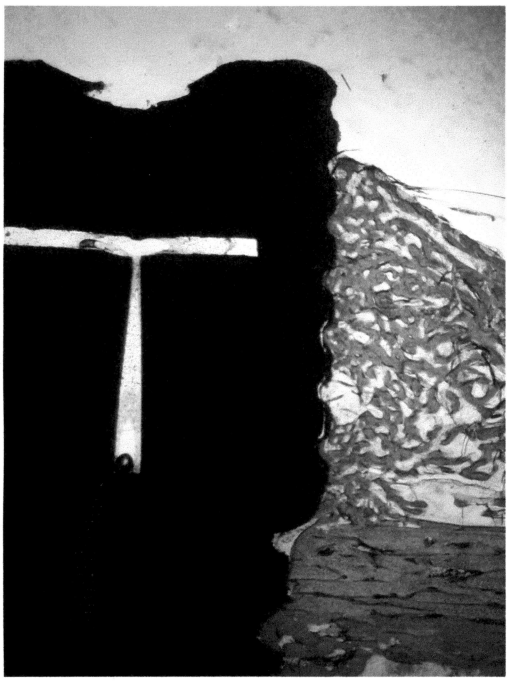


Figure 46. Bone apposition / retention beyond the junction between part 1 and part 2 (low power slide 4X).

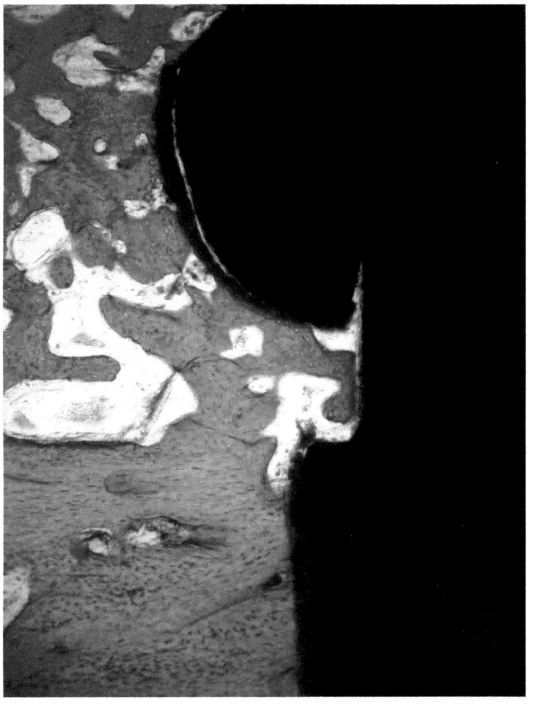


Figure 47. Bone apposition / retention beyond the junction between part 1 and part 2 (high power slide 20X).

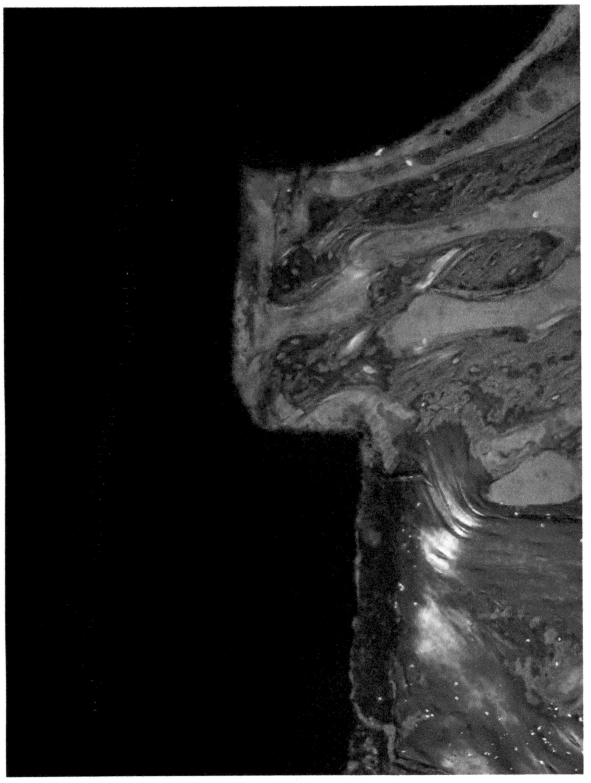


Figure 48. Bone apposition / retention at the junction of pat one and part two of the profilr implant (very high power slide 40X).

Table 1. BIC% group one measured from the top of the implant to the inferior border of the superior cortical plate.

Rabbits	BIC% from top of the implant to the inferior border of the superior cortical plate	
	Control implant	Experimental implant
Subject 1	34.00	54.70
Subject 2	51.70	66.30
Subject 3	22.70	52.00
Subject 4	85.20	58.80
Subject 5	54.60	68.50
Subject 6	70.50	62.40
Average	53.12	60.45
Standard deviation	22.92	6.48

Table 2. BIC% measured in group one over the whole length of the implant.

Rabbits	BIC% over the whole length of the implant	
	Control implant	Experimental implant
Subject 1	13.70	33.50
Subject 2	31.90	42.30
Subject 3	71.00	39.30
Subject 4	41.70	40.00
Subject 5	57.90	47.80
Subject 6	50.90	45.70
Average	44.52	41.43
Standard deviation	20.19	5.08

Group Two

New bone formation was noted in both experimental and control implants. The bone formation above the native crestal bone was more consistent and was confirmed on all the experimental implants in some cases above the implant platform as was noted clinically (figures 49, 50, 51). The control implants showed less bone formation over the cover screw (figures 52, 53). The presence of a junction between part one and part two of the experimental implant did not seem to have an effect of bone formation along the second part of the implant. (figures 54, 55, 56, 57).

When BIC% was measured from the top of the implant to the inferior border of the superior cortical plate, the BIC% ranged from 68.6% to 100 % with an average of 85.65% for the control group and from 74% to 100 % with an average of 88.78% for the experimental implant (table 3). Table 3 shows the BIC% form the top of the implant to inferior border of the superior cortical plate for the experimental implants and the control implants.

When BIC% was measured over the whole length of the implant, the BIC% ranged from37.4% to 53.12% with an average of 43.48% for the control group and from 39.2% to 51.1% with an average of 45.7% for the experimental implant (table 4). Table 4 shows the BIC% over the whole length of the control and experimental implants.

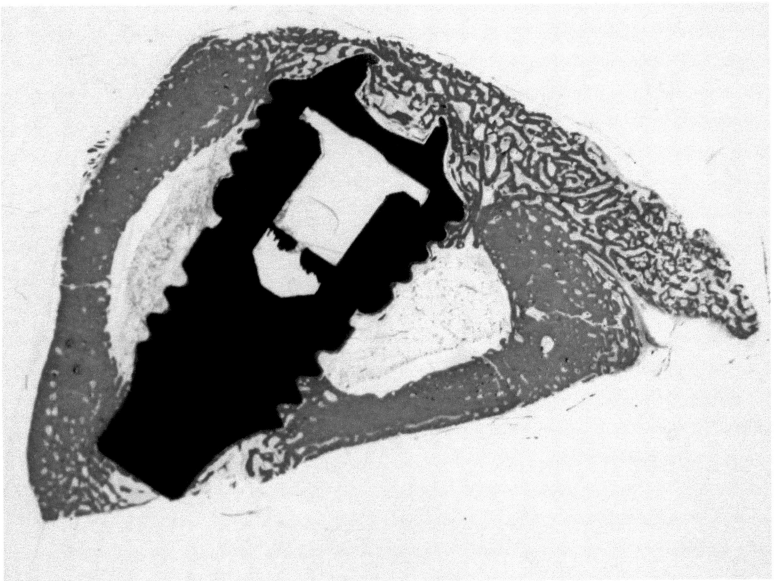


Figure 49.Experimental implant slide showing bone growth above the native bone level and beyond the implant platform.

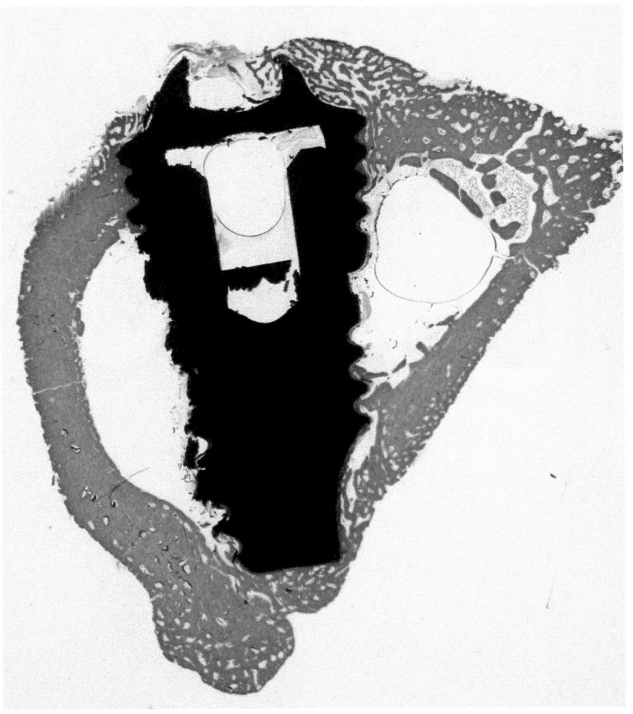


Figure 50. Experimental implant slide showing bone growth above the native crestal bone level to the top of the implant platform.

Figure 51. Experimental implant slide showing bone growth above the native crestal bone level to the top of the implant platform.

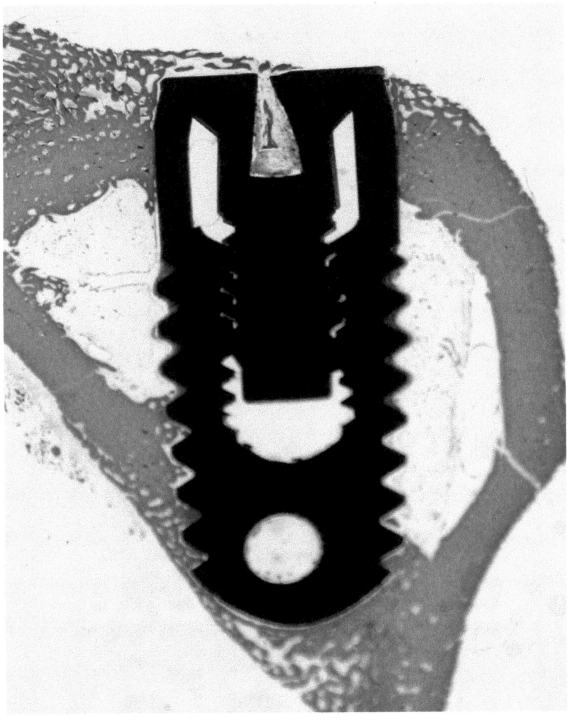


Figure 52. Control implant showing bone growth above the native crestal bone level and over the cover screw.

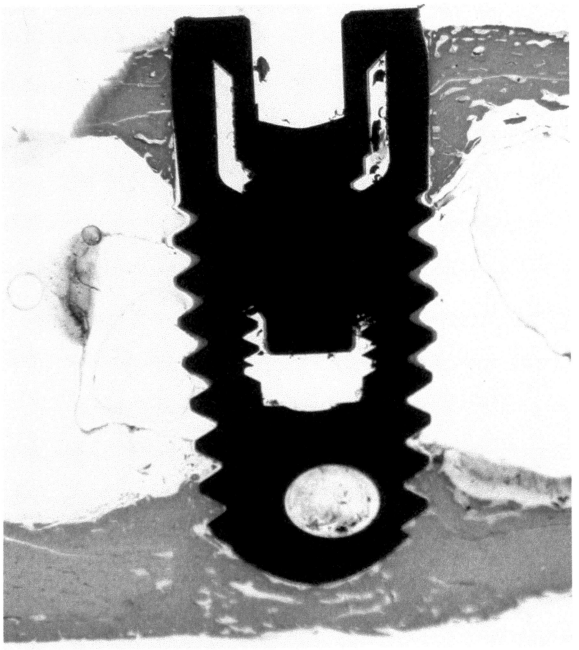


Figure 53. Control implant showing no bone growth over the cover screw.

Figure 54. Experimental implant slide showing bone apposition / retention over the 2nd part of the implant (medium power slide).

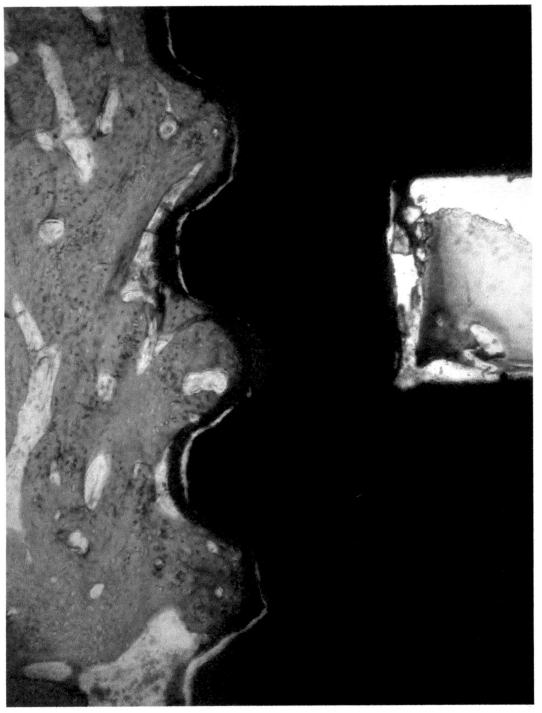


Figure 55. Experimental implant slide showing bone apposition / retention over the 2nd part of the implant (High power slide 20X).

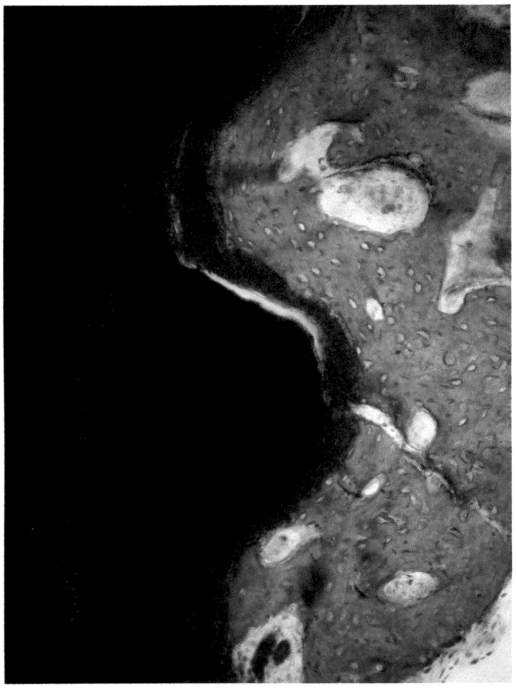


Figure 56. Experimental implant slide showing bone apposition / retention over the 2nd part of the implant (very high power slide 40X).

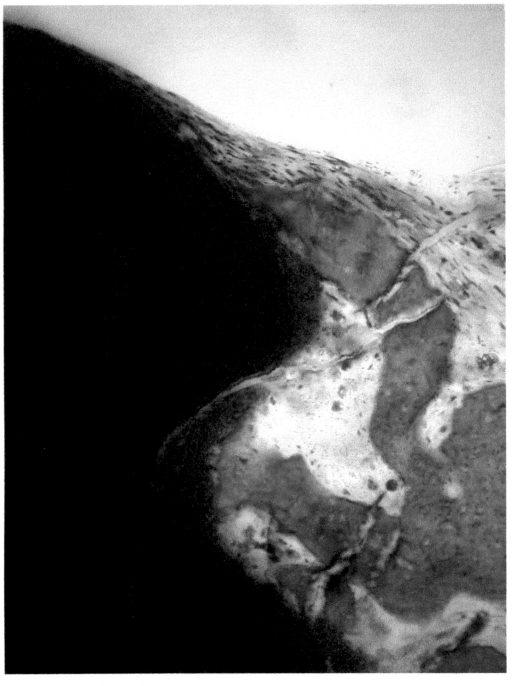


Figure 57. Experimental implant slide showing bone apposition / retention to the top of the 2nd part of the implant (very high power slide 40X).

Table 3. BIC% group 2 measured from the top of the implant to the inferior border of the superior cortical plate.

Rabbits	BIC% from top of the implant to the inferior border of the superior cortical plate	
	Control implant	Experimental implant
Subject 1	87.20	94.00
Subject 2	68.60	87.10
Subject 3	100.00	100.00
Subject 4	86.80	74.00
Average	85.65	88.78
Standard deviation	12.91	11.17

Table 4. BIC% group 2 measured over the whole length of the implant.

Rabbits	BIC% over the whole length of the implant	
	Control implant	Experimental implant
Subject 1	37.40	51.10
Subject 2	37.50	48.50
Subject 3	55.20	39.20
Subject 4	43.80	44.00
Average	43.48	45.7%
Standard deviation	8.37	5.23

Statistical Results

Group One

Using Wilcoxon Mann Whitney rank sum at a significance level of 0.05 there was no statistically significant difference (P=0.394) in the BIC% when measured from the top of the implant to the inferior border of the superior cortical plate between the Experimental and the control implants (figure 58).

Using Wilcoxon Mann Whitney rank sum at a significance level of 0.05 there was no statistically significant difference (P=0.240) in the BIC% when measured over the whole length of the implant between the experimental and control implant (figure 59).

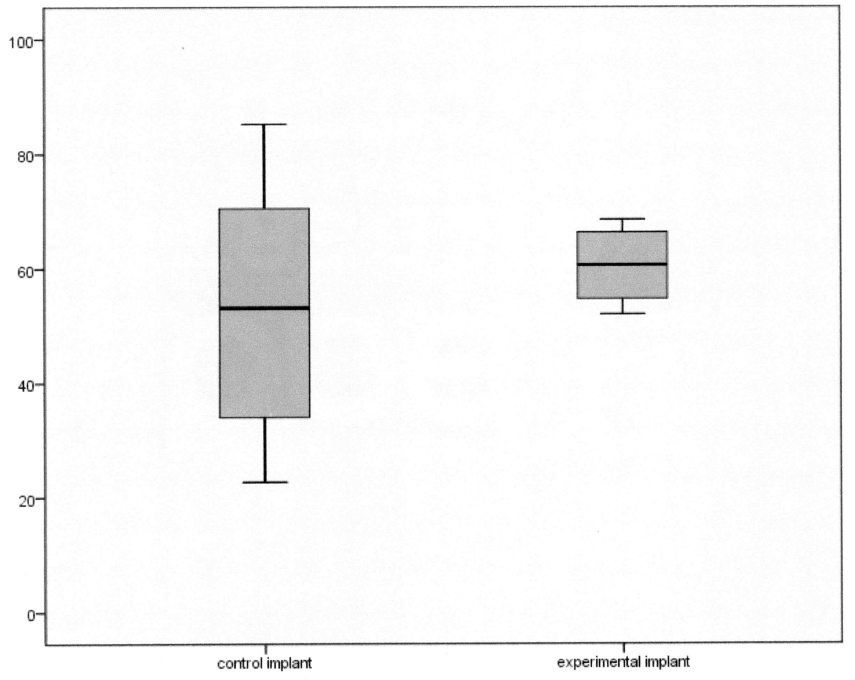


Figure 58. Box plot for group one BIC% when measured from the top of the implant to the inferior border of the superior cortical plate

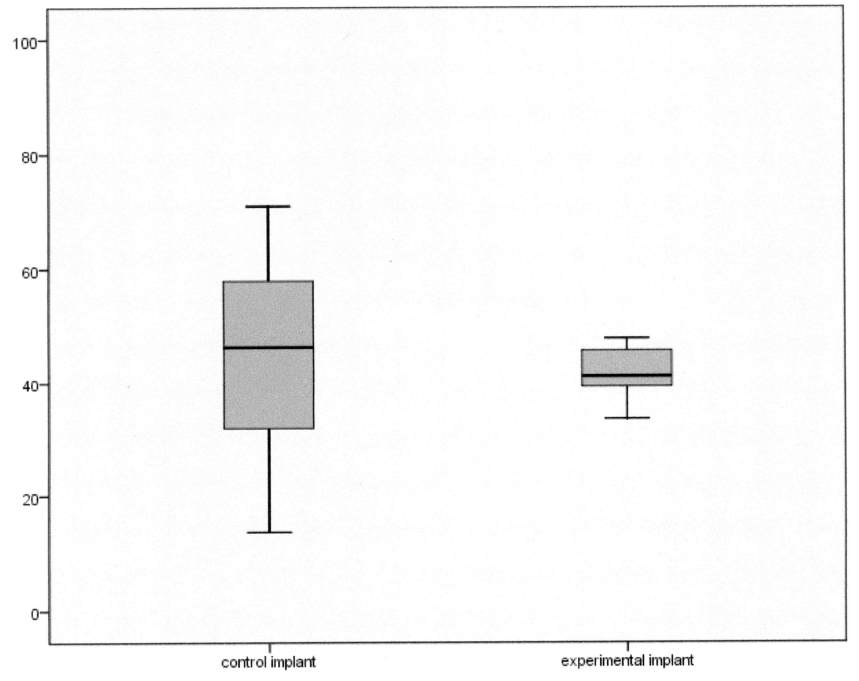


Figure 59. Box plot for group one BIC% when measured over the whole length of the implant

Group Two

Using Wilcoxon Mann Whitney rank sum at a significance level of 0.05 there was no statistically significant difference (P=0.200) in the BIC% when measured from the top of the implant to the inferior border of the superior cortical plate between the experimental and the control implants (figure 60).

Using Wilcoxon Mann Whitney rank sum at a significance level of 0.05 there was no statistically significant difference (P=0.343) in the BIC% when measured over the whole length of the implant between the experimental and the control implants (figure 61).

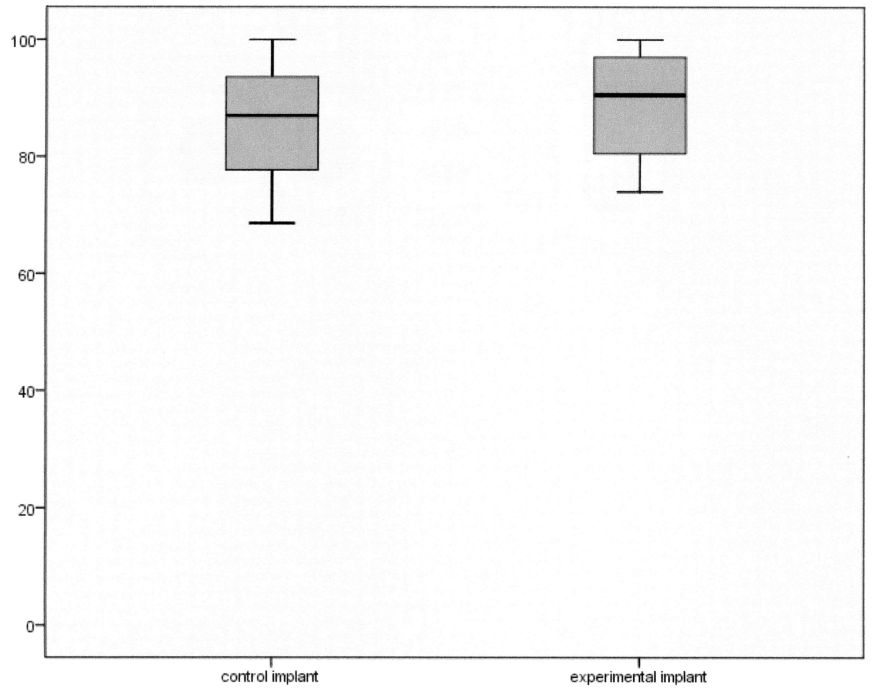


Figure 60. Box plot for group 2 BIC% measured from the top of the implant to the inferior border of the superior cortical plate

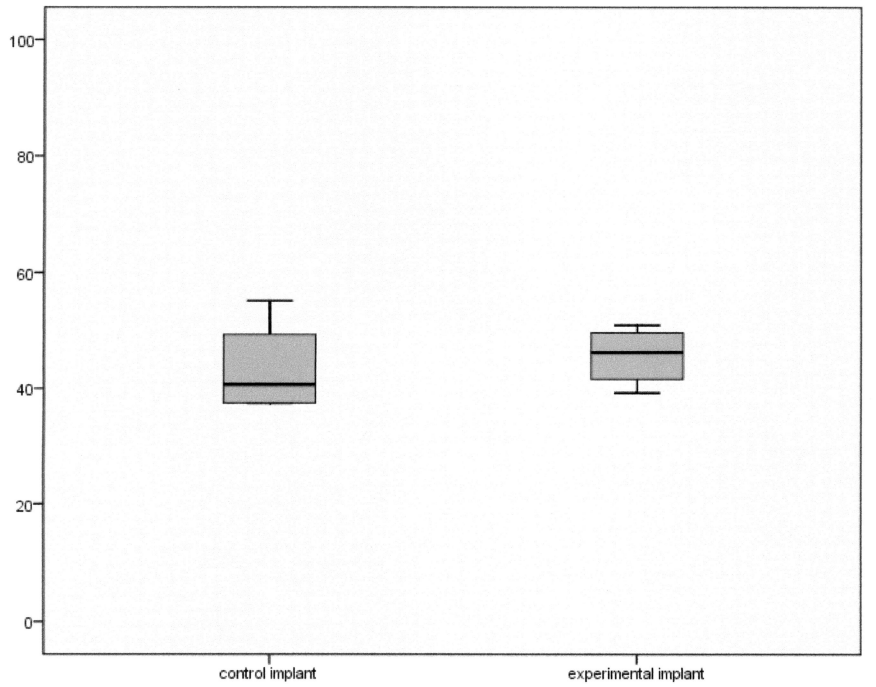


Figure 61. Box plot for group 2 BIC% measured over the whole length of the implant

CHAPTER FIVE

DISCUSSION

The critical amount of BIC needed for implant success is not fully quantified as it is dependent on the bone physiology of the study model, the site within the study model, healing period, loading conditions, implant design, surface treatment , surface topography and histomorphometric measurement methods. It is also a dynamic process that changes with bone remodeling. However if all these factors are standardized within a study it is a valid method to demonstrate the difference of bone reaction to different implant designs and surface treatments. Different authors have reported different BIC%, in humans studies have suggested 50% in loaded implants [29]. Others reported a range of 30%-96% in unloaded implants [30, 31, 32] and 25% to 83% in loaded implants [33, 34, 35, 36]. In animal canine models the BIC% also had high variation and was related to implant surface treatment and topography. In rabbit tibiae a study reported and average of 31% of BIC% on TiO2 surface blasted implants and 39% when the blasted surface was modified with fluoride [37]. Another study compared the BIC% in rabbit tibiae between Ca ion deposited implants and machine implants where the Ca ion deposited implants had a BIC% of 49% versus 18% for the machined implants [38].

In the current study the average BIC% when measured for group one from the top of the implant to the inferior border of the superior cortical plate was 53.12% for the control implant and 60.45% for the experimental implant while when measured over the

whole length of the implant it was 44.5% for the control and 41.4% for the experimental implant. These averages compare favorably to the previously mentioned studies, however the variation in the BIC% between the study subjects differed, the control implants BIC% varied between 22.7% - 85.2% while the experimental implants BIC% was more consistent and varied between 52% - 68.5%. The same was observed when the BIC% was measured over the whole length of the implant were it varied between 13.7% - 71% in the control implants and between 33.5% - 47.8% in the experimental implants.

In group two the average BIC% when measured from the top of the implant to the inferior border of the superior cortical plate was much higher and consistent in both the control implants and the experimental implants. The average for the control implants was 85.65% ranging between 68.8% - 100% while for the experimental implants the average was 88.78% ranging between 74% - 100%. When the BIC% was measured over the whole length of the implant the average dropped considerably to 43.48% ranging between 37.4% - 55.2% for the control implants and 45.7% ranging between 39.2% - 51.1% for the experimental implants. The large difference between the BIC% averages can be attributed to the bone physiology and anatomy of the rabbit tibia where between the two cortical plates a hollow marrow space exists with little or no bone, thus reducing the BIC% when measured over the whole length of the implant.

Bone apposition over the second part of the experimental implant and the healing abutment of the control implants was proven possible. It was inconsistent in group one and varied between the test subjects, in some it proceeded to the top of the second part while in other samples it did not and instead of bone tissue soft tissue was noted. A possible explanation of the inconsistency has to with maintaining the space around the

second part for bone apposition. In the first subjects the incision was done directly over the implant site and while suturing it was noticed that the tissue was collapsing over the second implant part. That was modified in the latter subjects by placing the incision to the side of the implant site and tunneling the periosteam around the implant site. Another factor is the height of the second part extending beyond the existing level of the bone. For the experimental implant that was 4mm in group one, and considering that the head of the tibia on average had a width of 8-10 we can recognize that tenting the periosteam over that part and maintaining the space without collapse can be challenging. In group two, bone apposition was consistent in all the experimental implants which explains the higher BIC% around the second part. That also has to do with maintaining the space around the second part of the experimental implant which was possible with the modified incision and the fact that in group two only the scalloped part of the experimental implant (2mm) was left extending over the native bone level.

The presence of a junction between part one and part two of the experimental implant did not seem to have an effect on bone apposition regardless whether that junction was at the native bone level or below it and bone formation was noted at the junction in the histology slides.

CHAPTER SIX

CONCLUSION

Within the limits of this study, it can be concluded that:

1. Bone apposition / retention around the second part of the experimental implant and beyond the existing native bone level is possible provided that space can be maintained; it was consistent up to 2mm above the native bone level.
2. The presence of a junction between part one and part two had no effect on bone apposition / retention.
3. Compared to the commercially available control implant, the experimental implant had similar BIC% but showed better bone adaptation in the histology slides around the scalloped second part than the healing abutment of the control implant.
4. The current study had a limited number of subjects in an extraoral unloaded environment and did not test the ability of the experimental implant to maintain the bone around the scalloped part over time, thus further studies are needed to verify these issues.

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