A RETROSPECTIVE EVALUATION OF VERTICAL BONE LOSS AROUND DENTAL IMPLANTS FOLLOWING IMMEDIATE PLACEMENT AND IMMEDIATE LOADING.

CANDIDATE:

Dr. E Muthray BSc (Wits), BDS (Wits), FCMFOS(SA)

I, Enesh Muthray, declare that this research report is my own work. It is being submitted in partial fulfilment of the requirements for the degree of Master of Dentistry, in the branch of Oral and Maxillofacial Surgery, at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination at this or any other university.

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Dr E Muthray

To my Parents, my wife and children.

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ABSTRACT

The immediate placement and loading of dental implants has many advantages and is an on-going focus of interest and research. Identifying factors that decrease vertical bone loss associated with implants might improve the prognosis of this protocol. This report evaluated survival (defined as the implant being present at the last review of the patient) and success (determined by the vertical bone loss around an implant) of immediately placed and loaded dental implants. Moreover, it set to determine whether site of placement and implant length had any influence on survival and vertical bone loss and thus have predictive value when immediately placing and loading a dental implant. The study was a retrospective clinical study consisting of a series of patients from an Oral and Maxillofacial surgeon's private practice. Forty implants in 17 patients were analysed by comparing orthopantomographic radiographs taken immediately post placement and at the final review visit. Survival was determined for the sample and within the 2 parameters mentioned (i.e. implant length and placement site). Bone levels were measured on the radiographs of the subject concerned. Distortion and variance of the radiograph machine was calculated and all measurements corrected for distortion. The rate of bone loss and survival was determined for the sample. Success, or vertical bone loss, was judged by the rate of vertical bone loss measured for the entire sample and also within the two parameters. Four sites of placement were assessed, anterior maxilla, posterior maxilla, anterior mandible and posterior mandible. Two implant lengths were assessed, < 15mm and ≥ 15mm. The results were then analysed for significance to see if site of placement or length of implant influenced survival or vertical bone loss around the implant. There were no implant losses and therefore survival was 100%. The average rate of bone loss for the sample was 0.80mm per annum, which is within the internationally accepted norm of 1.5mm in the first year of placement. As survival was

100%, no statistical analysis was done for this parameter. There were statistically significant differences in the rate of bone loss with regards to the site that an implant was placed. The rate of loss was highest in the posterior maxilla, followed by the anterior mandible and then the posterior mandible. The anterior maxilla had the lowest rate of bone loss. Implant lengths of 15mm or longer had a statistically significant, higher rate of bone loss than implants shorter than 15mm. This study concludes that different implant sites have different success outcomes and that immediately placed and loaded implants, placed in the anterior maxilla, will be associated with less marginal bone loss. Similarly, with respect to implant length, implants shorter than 15mm enjoyed diminished bone loss.

These results are expected in some aspects (i.e. survival and rate of bone loss of the sample as a whole), but are unusual in others (i.e. the rate of bone loss in the anterior maxilla being lower than traditionally more predictable sites, and rate of bone loss being less in shorter implants). It could be attributed to inherent difficulty in accurately assessing images in the anterior maxilla on an orthopantomographic radiograph, which would explain the results with respect to site of placement, or a number of flaws in the design of the study. These assumptions are made empirically, as no study I am aware of has specifically compared vertical bone loss within parameters of length and site.

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1. INTRODUCTION AND REVIEW OF THE LITERATURE

1.1 Introduction

Implant therapy is increasingly recommended in dentistry and provides a highly successful option for tooth replacement. Implants are presently proposed for the treatment of any type of edentulism and are placed in all segments of the jaw.[1] At inception, dental implantology advocated a 2 stage surgical procedure providing for load free, submerged healing, to ensure predictable osseointegration.[2] However, extended integration periods and multiple surgeries, with increased costs, tend to diminish patient acceptance of implant therapy.[2,3] This traditional, time-consuming protocol, was acknowledged to be empirical in nature.[4]

Shortening the overall treatment time and number of surgeries is obviously desirable. Immediate loading of implants placed in edentulous jaws was introduced and was the first step to overcoming the problems associated with conventional methods of implant placement and loading. In 1990, the first longitudinal clinical trial concluding that implants could be loaded immediately or early in the mandible of selected patients, was published.[5]

The problem of loss of the papilla, soft tissue inadequacies and length of time from extraction to prosthesis were still issues of concern, even though a second surgical procedure was eliminated and treatment length and cost were reduced.

Immediate placement and immediate loading protocols seek to provide the patient with a restorative solution that circumvents the difficulties associated with conventional two stage dental implantology. This protocol has the potential to maximally preserve hard and soft tissue.[4]

Studies on immediate placement and immediate loading have shown high survival rates and high success rates.[4,6-8] This protocol reduces discomfort, treatment time and cost, eliminates the need for a transitional provisional appliance and preserves bone height and width in the

residual alveolar ridge.[9] No study has investigated the relationship between marginal bone loss as a marker of success in immediately placed and loaded dental implants. Nor has a study assessed the influence of placement site and implant length on the rate of marginal bone loss. The following report attempts to establish this.

1.2 Literature review

1.2.1 History of implantology

The first clinical application for endosseous implants was in the dental rehabilitation of fully edentulous jaws,[10] but the actual discovery of "osseointegration", using titanium metal, is attributed to Dr. Per-Ingvar Branemark in the late 1950's.[11,12] Although other researchers experimented with other metals, titanium was the only material with properties that allowed integration with host tissues, with no resultant adverse effects.[13] The discovery made by Dr. Branemark occurred during research on the activity of bone marrow in rabbits using a procedure called vital microscopy. He found that titanium chambers he had implanted into rabbits became difficult to remove after a few months due to bone growth around the implant. Further studies revealed a unique relationship between titanium and bone and he coined the term "osseointegration" which he defined as "the structural and functional connection between ordered living bone and a load-carrying implant at the light microscopic level". This was the start of dental implantology as we know it today.

The initial protocol, as advised by Branemark, was a two staged procedure.[11,12,14] He believed that for osseo-integration to take place, the implant body had to be placed in bone and submerged for 4 to 6 months.[4,11] There should be no load or function placed on the unit as even the slightest motion (micromotion) would prevent osseointegration.[14,15] If the "micromotion" threshold was exceeded, osseointegration would not occur.[2,16] A second

surgical procedure was then undertaken to expose and load the implant after the healing period had taken place.

Various healing times were evaluated by Branemark and associates, and it was determined that shorter healing times resulted in failure of the implants.[12] They suggested that a healing time of 3 months was required in the mandible and 6 months in the maxilla.

Mobility of the implant during the 3-6 month healing phase could lead to the formation of fibrous tissue between the implant surface and the surrounding bone, preventing osseointegration and leading to the failure of the implant.[17] For osseointegration to occur, the implant must be immobile in the healing tissue after placement and excessive relative motion or micromotion of an implant in healing bone would prevent proper bone regeneration (osseointegration) and lead to bone repair, which is characterised by the formation of scar tissue at the interface of the bone and implant surface.[12,18]

Szmukler-Moncler *et al*,[19] speculated that there were 4 possibilities which could explain the required healing times:

1. Too early loading could result in fibrous encapsulation of the implant and thus prevent osseointegration.
2. Preparation of the implant site could result in overheating of the bone and lead to necrosis. This tissue needs to undergo healing and until then, the bone will not be capable of supporting an implant.
3. During the healing period, the bone to implant contact is less optimal and loading would not be well tolerated.
4. The bone adjacent to the bone-implant interface needs time to remodel and during the remodeling phase, the ability to support an implant would be compromised.

The traditional 2 stage protocol for implant placement has been shown to have a success rate of 90-100%, [3,16,20] but there are a number of disadvantages associated with it.[2,3]

- Extended length of treatment time.
- Increased morbidity associated with two surgical procedures.
- Increased costs associated with two surgical procedures.
- Cosmetic compromise until final prosthesis is placed after the second surgical procedure.
- Loss of the dental papilla and derangement of the soft tissue architecture in the edentulous area due to the length of time required until a prosthesis is placed.
- Potential closure of prosthetic space.
- Loose and ill-fitting denture if used for temporization.
- Functional difficulty with respect to speech and mastication.
- Bone resorption immediately post extraction.
- Compromise in implant positioning due to resorption of the alveolar ridge post extraction.
- Early unwanted exposure of the implant (cover screw) leading to infection and peri-implantitis with marginal bone loss.

The conventional approach results in almost a year of reduced quality of life and great psychological stress for some patients.[9]

Researchers started to question the conventional protocol for implant supported dental restorations. The biological basis for this healing period had not been elucidated by the studies done by Branemark.[12] Subsequent research concluded that these healing times were empirical[4,12] and clinical and experimental research challenged the notion that extended healing times were required.[21] Observations made over a period of time revealed that some

implants could be loaded after shorter healing times and that they could, under certain circumstances, be loaded immediately after placement.[12] These studies eventually proved that the magnitude of the load, the nature of the loading and the nature of the bone of the implant site, were of greater importance in osseointegration than the time they were left to heal.[12] These factors played a significant role in determining the amount of micromotion that could be tolerated and still allow osseointegration. It was found that if micromotion was kept under 150µm,[4,12] then osseointegration would be possible. The crucial factor for successful osseointegration is the stability of the implant during the healing phase.[12] If movement at the bone-to-implant interface is kept below a certain threshold, successful osseointegration would occur. Timing of the loading of the implant may therefore not be the critical issue but rather keeping micromotion below threshold.

Thus began the first tentative steps down the road to immediate loading of dental implants.

1.2.2 The immediate placement concept

The immediate dental implant is an attempt to obtain osseointegration and bone regeneration in an extraction site and is defined as placement of an implant immediately into the fresh extraction socket.[22] After exodontia, the natural pattern of bone resorption can result in a deficient ridge, which may be a problem for future implant placement.[23] Forty to sixty percent of the remaining alveolar bone may be lost after extraction and the resorptive and remodeling process may be associated with apical and lingual loss of ridge anatomy, which can oblige an unfavorable angulation of the implant placed in a delayed protocol.[22]

Immediate placement has the following advantages:

- Modifies the natural pattern of ridge resorption after exodontia

- Minimal use of surgical drills
- Decreased risk of bone necrosis because there is decreased surgical trauma[22]
- Rapid bone remodeling and healing.

Hassan et al, claim that the immediately placed dental implant avoids facial bone resorption,[22] (which is 25% within the first year after tooth extraction[24]), however there are have been subsequent reports indicating facial bone loss with immediate placement. There is good implant positioning and reduced treatment time.[22] This treatment design maintains the bone and soft tissue, enhances the aesthetics and the protocol has been used for around 20 years.[22] Survival rates are as high as the traditional 2-stage protocols and it is regarded as a predictable and successful treatment option.[7]

1.2.3 The immediate loading concept

The disadvantages associated with the conventional 2-stage placement protocol have led to significant patient perceived obstacles,[3] which immediate loading circumvents. Survival and success of immediately loaded implants are comparable to conventionally loaded implants.[2,4] There are 3 accepted implant loading periods, i.e. late (after 3 to 6 months), early (within 3 months after placement) and immediate loading,[8] although the International Team for Implantology (ITI) recommends the Advanced, Straight Forward, Complex classification of loading protocols, i.e. immediate restoration (restoration placed within 48hrs of implant placement, but not in occlusion), immediate loading (restoration placed within 48hrs of implant placement, but in occlusion), conventional loading (restoration is placed after a healing period of 3 to 6 months), early loading (restoration is placed in occlusion at least 48 hrs after placement, but not later than 3 months afterwards) and delayed loading (restoration is placed some time later than 6 months). Immediate loading of oral implants has been

defined as “a situation where the superstructure is attached to the implants no later than 72 hours after placement”,[4] although some authors demand a 48 hour time frame.[4,23]

Abinitio, immediate loading was limited to the restoration of the edentulous mandible where good bone quality and the possibility of cross arch splinting minimized micromotion.[25-27] Today this protocol is used in single tooth implants, in any site and even in fresh extraction sockets. The placement of a provisional crown sculpts the soft tissue providing immediate aesthetic relief whilst protecting the soft tissues.[4] Moreover, the need for two surgical procedures is eliminated.

Complications can arise from immediately loading an endosteal implant, e.g. fibrous tissue encapsulation if micromotion is not kept below threshold and more crestal bone loss when compared to conventional protocols.[2] Despite this, the success rate of immediately loaded implants is as high as that of the 2 stage protocol and as such can be used with a high degree of predictability as long as certain criteria are met.[2,4,3,12,23,28] These are primary stability, sufficient bone quality and elimination of micro-movement.[27]

Immediate loading reduces treatment time and decreases alveolar bone loss that accompanies traditional treatment methods following tooth loss.[4] Treatment costs are reduced and there is immediate cosmetic satisfaction for the patient. Several studies have helped this technique to become a routine clinical procedure,[22] although, further investigation is needed to identify the different factors that could influence the outcome of this treatment protocol.

2. AIMS AND OBJECTIVES

The following research report investigates the survival and success of implants placed and loaded immediately. The influence of implant length and the site of placement on implant survival and success will be assessed.

3. MATERIALS & METHODS

3.1 Study design

3.1.1 Data collection

This retrospective review study consisted of a sample of subjects from an Oral and Maxillofacial surgeon's private practice. The records of 17 patients who had immediate dental implants placed and loaded were selected. 40 implants were assessed for survival (i.e. being present on the last radiograph, a minimum of six months post placement) and the surviving implants assessed for success (determined by the rate of bone loss). Marginal bone levels of the immediate, post placement orthopantomographic radiograph and the orthopantomographic radiograph at the last review visit were measured and compared. The amount of vertical bone loss of the implant for the given period was calculated. Each implant had to be in function for at least six months. The bone loss was recorded in table form and measurements were corrected for distortion and variance of the radiographic machine. The average annual rate of bone loss was determined for our sample. This was then tested for statistical significance within two parameters, namely:

- Site of placement
- Length of implant

3.1.2 Radiographic examination

Radiographic examination was performed on standardized orthopantomographic radiographs. The same orthopantomographic machine was used and the radiographs were taken by the same practioner ensuring repeatable patient positioning as per manufacturers

recommendation. The machine produced analogue images on plain radiographic film. The magnification factor of the machine was calculated and corrected, the method of which is explained in the paragraphs that follow.

An implant was deemed to have survived if it was still *in situ* on the last assessed radiograph. Success of the implant was determined using one of the criteria for success as advocated by Albrektsson,[29] namely, peri-implant bone resorption less than 1.5 mm in the first year of function and less than 0.2 mm in the following year. There was no clinical interaction with the patient sample.

Measurements of bone-level changes were done by assessing the plain film radiographs on a light box without the aid of magnification. These measurements were recorded mesial and distal to each implant with a millimeter ruler, measuring the distance between the top of the implant head shoulder (Figure 1) and the most coronal level of direct bone-to-implant contact, and an average value was calculated for each implant. The bone-level taken immediately after implant placement was considered the baseline for further measurements. The measurements were recorded to the nearest 0.5 mm.

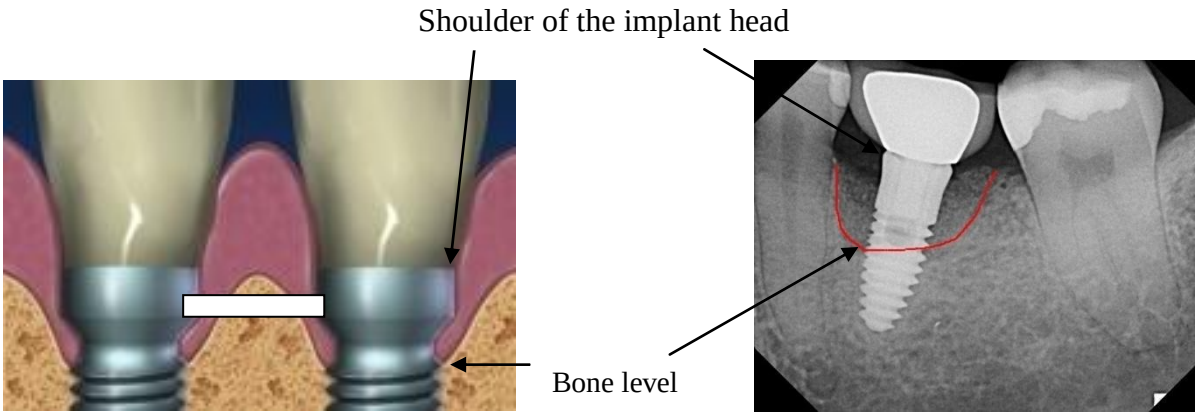


Figure 1: Points of reference for bone loss measurements.

3.1.3 Determination of distortion of radiograph machine

Radiographic distortion was determined by taking a radiograph with stainless steel balls of 10mm diameter held between the teeth in the central incisor and first molar sites on either side of the jaws. The image of the balls was then measured on the radiographic films in both the vertical and horizontal plane and compared with the actual sizes (Figure 2).

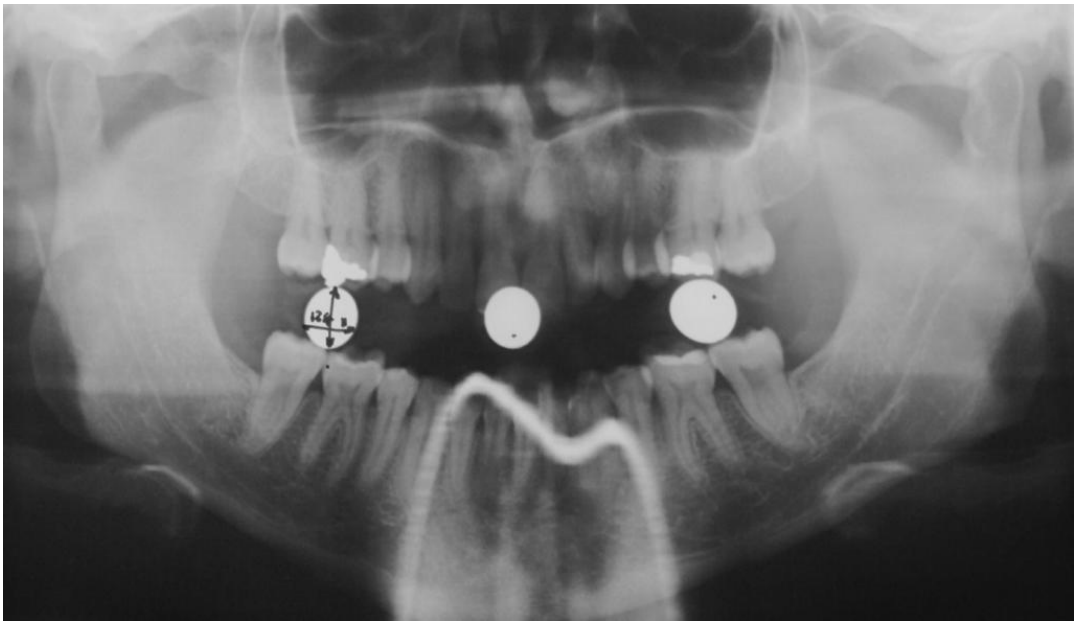


Figure 2: Orthopantomograph used in calculating distortion of the radiograph machine

Three different orthopantomographs were taken and the stainless steel balls measured. The sets of measurements were then analysed and distortion and variance of the radiographic machine calculated.

The following formulae were used to determine the distortion factor (DF):

Equation 1: calculation of distortion factor

- DF x actual dimension(AD) = radiograph dimension (XD)
- DF x 10mm = XD

- DF = XD/10mm

The formula for correction of the data is shown below:

Equation 2: correction to actual dimension:

- Actual dimension = XD/DF

3.1.4 Statistical analysis

The data was statistically analyzed with statistical programme R [version 2.7.0 (2008-04-22), the R foundation for statistical computing]. R is a programming language and software environment for statistical computing and graphics. The R language has become a *de facto* standard among statisticians for developing statistical software, and R is widely used for statistical software development and data analysis. R provides a wide variety of statistical and graphical techniques, including linear and nonlinear modeling, classical statistical tests, time-series analysis, classification, clustering, and others.

This programme was used to produce descriptive analysis and regression models to determine the relationships between the rate of bone loss and the site and length of each implant respectively. The level of significance chosen was 0.05.

The null hypothesis was tested using the t-test in R. The t-test shows difference within the parameters and whether that difference is significant or not. The probability of the t-test (Pr(>[t]) shows how the t-value obtained in the study compares to a standard t-test graph and according to the level of significance chosen, whether the value is significant or not, i.e. a value of greater than 0.05 would not be significant and less than 0.05 would be significant.

A multiple R squared value shows the fit of the statistical regression model to the actual data of the study. The closer the value is to 1, the better the fit.

3.2 Data evaluation

3.2.1 Methods of evaluation of implants

The presence of implants on the final radiograph was compared to the initial radiograph and the failures noted. Of the surviving implants, the immediate post placement radiograph and radiograph taken at the last review (6 months or longer post placement), were compared. The difference in marginal bone levels was recorded in millimetres by the same assessor. The data was then corrected for distortion for each implant and tabled (Table 2). The rate of marginal bone loss for the sample was calculated and recorded.

3.2.2 Criteria used for evaluation of implants

The following criteria were used:

1. Implant presence in the final radiograph.
2. Level of marginal bone on the orthopantomographic radiograph.
3. Site of placement.
4. Length of the implant.

Four sites of placement were defined:

1. Anterior mandible (the area between and including the left and right lower canines).
2. Posterior mandible (the area distal to the canines on either side of the mandible).
3. Anterior maxilla (the area between and including the left and right upper canines).
4. Posterior maxilla (the area distal to the canines on either side of the maxilla).

Implant lengths were divided into 2 groups, i.e. less than 15mm and 15mm and longer.

4. RESULTS

The study sample consisted of 37 immediately placed and immediately loaded standard Southern® implants (Centurion, Gauteng, South Africa) and 3 Nobel Replace® implants (Nobel Biocare, Zurich, Switzerland) from 17 patients. Some implants were part of a reconstruction which included the use of zygomaticus implants. 19 of these implants had cross arch stabilization. 3 implants were part of a zygomaticus protocol without cross arch stabilization. In these cases only the standard implants were included in the sample. Nine were splinted with cross arch stabilization, 4 cases were splinted without cross arch stabilization and there were 5 lone standing implants. None of the cases involved bone grafting procedures. The initial data collection is seen in table 1.

Table 1- Raw data collected

Implant no	Site of placement	Length of implant (mm)	Measured bone loss (mm)	Time in-situ (months)
1	anterior maxilla	15	2	24
2	anterior maxilla	15	1	24
3	posterior mandible	15	0	16
4	posterior maxilla	15	5	16
5	posterior maxilla	15	0	16
6	posterior mandible	15	0	16
7	anterior maxilla	16	2	24
8	posterior mandible	18	3	30
9	anterior mandible	15	4	30

10	anterior mandible	15	2	30
11	posterior mandible	18	3	30
12	posterior maxilla	13	1	15
13	posterior maxilla	11.5	5	15
14	posterior mandible	15	0	15
15	anterior mandible	15	3	15
16	anterior mandible	15	4	15
17	anterior mandible	15	3	15
18	posterior mandible	15	2	15
19	anterior maxilla	13	0	12
20	anterior maxilla	13	0	12
21	anterior maxilla	13	0	12
22	anterior maxilla	13	0	12
23	anterior maxilla	13	0	12
24	anterior maxilla	10	0	14
25	posterior mandible	10	2	8
26	posterior mandible	15	2	8
27	posterior mandible	15	4	12
28	anterior maxilla	16	2	24
29	posterior maxilla	15	2	36
30	anterior maxilla	15	2	36
31	anterior maxilla	13	2	12
32	anterior maxilla	13	1	12

33	anterior maxilla	13	0	18
34	anterior maxilla	13	0	18
35	posterior mandible	10	0	18
36	posterior maxilla	13	0	6
37	posterior mandible	15	0	6
38	anterior mandible	15	0	6
39	anterior mandible	15	0	6
40	posterior mandible	15	0	6

4.1 Correction for distortion and variance of the radiographic machine

Radiograph measurements of first orthopantomograph:

Right ball = 12mm (horizontal) x 13mm (vertical)

Centre ball = 10mm (horizontal) x 13mm (vertical)

Left ball = 16mm (horizontal) x 13mm (vertical)

Radiograph measurements of second orthopantomograph:

Right ball = 12mm (horizontal) x 13mm (vertical)

Centre ball = 11mm (horizontal) x 13mm (vertical)

Left ball = 15mm (horizontal) x 13mm (vertical)

Radiograph measurements of third orthopantomograph:

Right ball = 12mm (horizontal) x 13mm (vertical)

Centre ball = 12mm (horizontal) x 13mm (vertical)

Left ball = 16mm (horizontal) x 13mm (vertical)

No variance was noted in the distortion of the vertical dimension and as this study considered only vertical bone loss, all vertical measurements had the same distortion factor. Thus a distortion factor of 1.3 in the vertical dimension at all three sites on the orthopantomographic machine was used in the study.

4.2 Data corrected for radiograph distortion and variance

Table 2 shows the actual amount of bone loss, in millimetres, of each implant assessed.

Table 2: Data corrected for distortion

Implant no	Site	Length (mm)	Corrected bone loss (mm)	Time in-situ (months)
1	anterior maxilla	15	1.5	24
2	anterior maxilla	15	0.8	24
3	posterior mandible	15	0	16
4	posterior maxilla	15	3.8	16
5	posterior maxilla	15	0	16
6	posterior mandible	15	0	16
7	anterior maxilla	16	1.5	24
8	posterior mandible	18	2.3	30
9	anterior mandible	15	3.1	30
10	anterior mandible	15	1.5	30
11	posterior mandible	18	2.3	30

12	posterior maxilla	13	0.8	15
13	posterior maxilla	11.5	3.8	15
14	posterior mandible	15	0	15
15	anterior mandible	15	2.3	15
16	anterior mandible	15	3.1	15
17	anterior mandible	15	2.3	15
18	posterior mandible	15	1.5	15
19	anterior maxilla	13	0	12
20	anterior maxilla	13	0	12
21	anterior maxilla	13	0	12
22	anterior maxilla	13	0	12
23	anterior maxilla	13	0	12
24	anterior maxilla	10	0	14
25	posterior mandible	10	1.5	8
26	posterior mandible	15	1.5	8
27	posterior mandible	15	3.1	12
28	anterior maxilla	16	1.5	24
29	posterior maxilla	15	1.5	36
30	anterior maxilla	15	1.5	36
31	anterior maxilla	13	1.5	12
32	anterior maxilla	13	1.5	12
33	anterior maxilla	13	0	18
34	anterior maxilla	13	0	18

35	posterior mandible	10	0	18
36	posterior maxilla	13	0	6
37	posterior mandible	15	0	6
38	anterior mandible	15	0	6
39	anterior mandible	15	0	6
40	posterior mandible	15	0	6

4.3 Analysis of the data

The sample consisted of 40 implants. The implant lengths ranged from 10mm to 18mm. Fifteen implants were less than 15mm and 25 implants were 15mm or longer (Table 3).

15 implants were placed in the anterior maxilla, 6 implants were placed in the posterior maxilla, 7 implants were placed in the anterior mandible and 12 implants were placed in the posterior mandible (Table 4).

Table 3: Distribution of implants according to length

Implant length	Number of units
<15mm	15
≥ 15mm	25

Table 4: Distribution of implants according to site of placement

Implant site	Number of units
Anterior maxilla	15
Posterior maxilla	6
Anterior mandible	7
Posterior mandible	12

4.3.1 Survival

No implants in the study were lost, so survival was 100%.

4.3.2 Success

4.3.2.1 Rate of bone loss of sample

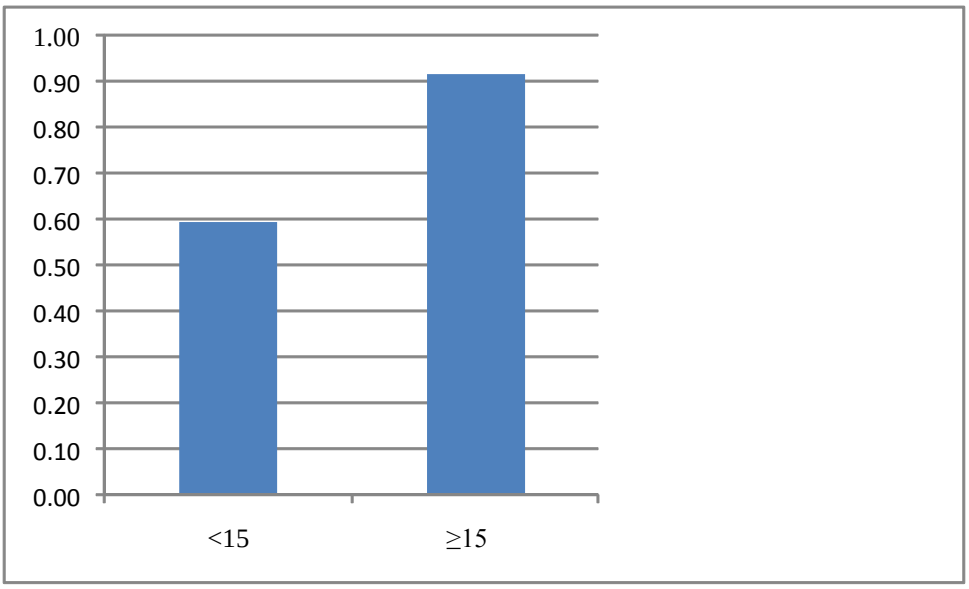
The average rate of bone loss was calculated per month and then extrapolated to an annual amount (total bone loss/months of observation x 12 = annual bone loss). Forty observations were made and the average bone loss was 0.80mm ± 0.97mm (range 0.0mm-3.1mm).

4.3.2.2 Rate of bone loss associated with different implant lengths

Twenty five observations were made in the ≥15mm group and the bone loss associated with these lengths (Figure 3) was 0.92mm ± 0.96mm (range 0.0mm-3.1mm).

There were fifteen observations in the <15mm group and bone loss was 0.6mm ± 1.00mm (range 0.0mm-3.04mm).

Figure 3: Rate of bone loss with respect to implant length



4.3.2.3 Rate of bone loss associated with different sites of placement

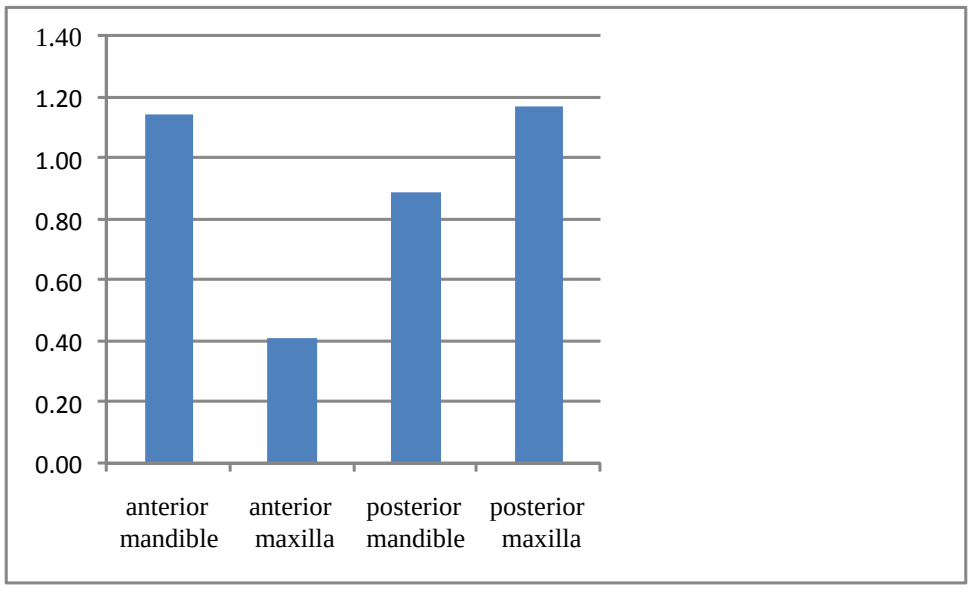
Seven observations were made in the anterior mandible and the average rate of bone loss was 1.14mm± 0.97 (range 0.00mm-2.48mm).

Fifteen observations were made in the anterior maxilla and the average rate of bone loss was 0.41mm ± 0.54 (range 0.00mm-1.50mm).

Twelve observations were made in the posterior mandible and the average rate of bone loss was 0.89mm ± 1.11 (range 0.00mm-3.10mm).

Six observations were made in the posterior maxilla and the average rate of bone loss was 1.17mm ± 1.40 (range 0.00mm-3.04mm) (Figure 4).

Figure 4: Rate of bone loss with respect to site



4.3.3 Statistical analysis

4.3.3.1 Rate of bone loss associated with different implant lengths

Statistical analysis reveals significant difference in the rate of bone loss associated with the different lengths of the implant (Table 5). Implants of ≥ 15mm had a higher rate of bone loss than the shorter implants.

Table 5: Statistical analysis of rate of bone loss related to implant length

Implant length	Average(mm)	Standard deviation (mm)	t-value	Probability test Pr(>[t])
<15	0.59	0.25	2.37	0.02
≥15	0.92	0.19	4.7	3.36

Multiple R-squared was 0.42

4.3.3.2 Rate of bone loss associated with different sites of placement

The statistical analysis shows that there is a significant difference in the rate of bone loss associated with the different sites of placement of the implants (Table 6). The anterior maxilla shows the lowest rate of bone loss, followed by the posterior mandible and then the anterior mandible. The posterior maxilla showed the highest rate of bone loss.

Table 6: Statistical analysis of bone loss rate related to implant site

Implant site	Average(mm)	Standard deviation (mm)	t-value	Probability test Pr(>[t])
Anterior mandible	1.14	0.36	3.16	0.003
Anterior maxilla	0.41	0.25	1.66	0.11
Posterior mandible	0.89	0.28	3.21	0.003
Posterior maxilla	1.17	0.39	3	0.005

Multiple R-squared was 0.48

5. DISCUSSION

Immediate implant placement and provisionalization is time saving, usually requiring only one surgical intervention, and ensuring maximal protection of peri-implant tissue.[4] It allows immediate restoration of limited function as well as aesthetics.

Norton[3] evaluated the short term clinical outcome of single tooth implants placed in the maxilla, immediately loaded and immediately placed after tooth extraction. Twenty five patients and a total of 28 Astra-tech ST® implants were assessed from a private specialist practice. Implant survival was recorded along with marginal bone levels relative to a fixed point, 1 year after placement. A 96.4% survival was found in this study with a mean marginal bone loss of 0.4 mm and most implants showing no bone loss at all. In addition, it was concluded that the placement of the implant immediately after tooth extraction could yield favourable soft tissue aesthetics.

Other studies of immediate placement and immediate provisionalization procedures showed survival rates of 93.5 – 100%. [4,6,7,9,28-32]

Minimal immediate provisionalization criteria are suggested by Becker et al,[7] i.e. primary stability must be achieved, there must be at least 3mm of circumferential bone around the apex and there must be occlusal protection of the provisionals during the osseointegration phase.

In animal models, several groups found histological and histomorphometrical evidence of higher density of bone at the bone-to-implant interface and a more compact bone resulting from immediate loading.,[33] indicating a clinical and biological advantage to immediate loading of an implant.

Although a distinct minority, other studies found that failure is more likely for implants placed in fresh extraction sockets and with immediate loading,[33,34] .

Identifying factors that may influence survival and success of an immediately loaded implant is of obvious importance to minimize risk of failure.

This study assessed survival and success of immediately placed and immediately loaded dental implants and analyzed two potential variables which may influence outcome.

The study showed 100% survival of immediately placed and immediately loaded dental implants.

With regard to the rate of bone loss, this study found an average of 0.80mm per annum, which is within the international benchmark of peri-implant bone resorption (less than 1.5 mm in the first year of function and less than 0.2 mm in the following year).[29]

The variable of implant length has been shown by some studies to influence implant success and survival.[1,20,30-,32,33-38] A study done by Susarla *et al,*[34] states that for each 1-mm decrease in implant length, there was a corresponding 30% increase in implant failure at 1 year. The definition of a long implant as opposed to a shorter one is ambiguous, but the accepted line of division appears to be > 10mm or ≤ to 10mm, although some define the long implant as greater than 13mm.[38]

Yet again some evidence is available to support the contention that there is no association between implant length and cumulative implant survival rate.[38] Grant *et al,*[36] showed a 99% success rate using 8mm (short) implants in the posterior mandible.

The data from our study found no correlation between implant length and survival, and that implant lengths of 15mm or greater were associated with a higher rate of bone loss than the shorter implants.

The literature is divided on the influence of site on the survival of immediately placed and loaded implants. Some researchers find that site has no influence,[10,29,38-39] however others find site to be a significant factor in outcome.[34,38,41]

In our study, the site of placement had no influence on survival, but had a statistically significant influence on the rate of bone loss. The highest rate of bone loss was noted in the posterior maxilla, followed by the anterior mandible and then the posterior mandible. The lowest rate of bone loss is shown in the anterior maxilla.

The results of our study find that implant survival and rate of bone loss are consistent with data presented by other researchers. As far as bone loss associated with anatomical site and implant length is concerned these results are surprising as they do not concur with what would be empirically expected and has been detailed in the literature. It is well established that fixtures placed in the anterior mandible enjoy higher success rates and decreased levels of bone loss compared to other anatomical sites[33]. Moreover, longer implants have greater primary stability[42] and therefore prone to diminished bone loss. Our study finds that the anterior maxilla and shorter implants are associated with the least amount of bone loss. A possible explanation for this incongruity may be measurement error due to the inadequacy of the image quality of the anterior maxilla on orthopantomograph.

Bone loss following implant placement may be influenced by the quality of the bone, torque out values of the implant placed, the type of implant placed and various patient factors such as medical history, age and smoking history. These variables were not considered in our study and may be the reason for the incongruous results. In addition, in an attempt to achieve homogeneity of the sample, the sample size was reduced. Therefore the high survival rate may be skewed. Data was only collected from one centre, thus negating variability that arises from other practitioners. The study did not include any patient interaction, not allowing any clinical assessment of the implant. Having only the radiographic information allowed only a two dimensional assessment of vertical bone levels and the complete clinical assessment of implant success according to Zarb and Albrektsson[29] was not possible. Radiographic assessment only allowed information of the mesial and distal

bone levels. The buccal and lingual levels could not be assessed. Also, the accuracy of measurements is questionable in that analogue radiographs were used and the bone levels were measured manually and not computer aided. Insertion stability of the implants was not recorded by the treating surgeon, neither were the details of the restorative phase. However, to definitively comment on the accuracy of the rate of bone loss within the parameters investigated, one needs comparative studies from the literature. To our knowledge, there are no studies that compare bone loss associated with different implant lengths or implant sites, in immediately placed and loaded implants, therefore assumptions are empirical.

6. CONCLUSION

This study shows that implants that are placed and loaded immediately have a survival rate and rate of marginal bone loss that is comparable to conventional implant placement protocols and is in line with published data.

It also indicates that there is a lower rate of marginal bone loss around implants placed in the anterior maxilla and implants shorter than 15mm. These findings are not expected, but definitive assumptions cannot be made as there are no comparative studies in the literature. .

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