IMMEDIATE VERSUS DELAYED LOADING OF TWO UNSPLINTED IMPLANTS SUPPORTING A LOCATOR™ RETAINED MANDIBULAR OVERDENTURE. A RANDOMIZED CONTROLLED STUDY

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Abstract

Background: Implant supported mandibular overdentures (OVD) have been proposed as the gold standard for the treatment of edentulous mandibles. Although immediate loading may reduce the treatment time and improve the patient comfort without jeopardizing implant success, yet there is limited evidence on the clinical outcomes of immediate loading of 2 unsplinted implants supporting a mandibular OVD. The purpose of this randomized controlled trial was to evaluate the performance of 2 unsplinted implants supporting a Locator™ retained mandibular OVD in a 12-month post surgical period, using either an immediate or a delayed loading protocol.

Methods: Each patient received 2 implants 4.0mm in diameter and length ranging from 8-15mm. Locator™ retained mandibular overdentures were connected to the implants either immediately (IL) or 3 months post surgery (DL). The primary response variable was radiographic bone level change (RBLC) at 6 and 12 months post-surgery. Implant length, insertion torque value (IT), implant failure, prevalence of maintenance visits and prosthetic complications were also recorded.

Results: Thirty participants (15 in the IL and 15 in the DL groups) were evaluated at 12 months. The implant cumulative survival rate (CSR) was 100% and 93% for DL and IL, respectively. The mean RBLC from baseline to 1 year was 0.54 (±0.5) mm and 0.25 (±0.5) mm for DL and IL, respectively. A statistically significant difference was observed at 12 months interval ($p<0.02$) with a smaller RBLC in the IL group. IT and implant length were not correlated with RBLC. Also, no difference in frequency of maintenance visits and prosthetic complication was reported between the groups.

Conclusions: Immediate loading of 2 unsplinted implants supporting a Locator™ retained mandibular OVD seems to be a suitable treatment option. A significantly smaller RBLC was observed after 1 year of loading on IL implants when compared to DL. Furthermore, neither implant length nor IT seemed have an effect on RBLC 1 year after surgical placement.

Introduction

Progressive bone resorption of the edentulous ridge is a major concern when rehabilitation of the mandible with a complete denture is considered (1, 2). Complete mandibular dentures seem insufficient in re-establishing oral function, chewing efficacy and bite force (3). The introduction of implant-retained overdenture (OVD) prostheses has led to a paradigm shift in the management of complete edentulism. Hence, implant supported OVD have been proposed as the gold

standard treatment for the fully edentulous mandible (4). The long-term efficacy, clinical efficiency and patient satisfaction with this type of restorative solution have been successfully established in many retrospective and longitudinal trials (4, 5). According to the traditional loading protocol, dental implants are connected to the prosthesis when the process of osseointegration is considered completed. The recommended timelines before implants loading were established at 6 months and 3 months of undisturbed healing of maxilla and mandible respectively (6). For a long time, immediate loading of dental implants was considered detrimental for osseointegration. Evolution of implant systems, designs and surfaces has allowed for a shortened healing time without jeopardizing osseointegration and implant success rate (7). The new generation of implant surfaces were characterized by a moderately rough configuration that demonstrated higher bone to implant contact and faster bone deposition during the early healing phase (8). An average surface roughness (Sa) ranging between 1 to 1.5 μm seemed to provide a significantly higher bone to implant contact when compared to either smoother or rougher surface topographies (9). In addition to surface geometry, the chemical modification of the metal surface seemed to influence the rate of bone deposition, favoring faster bone maturation (10, 11). Recently a sandblasted surface treated with fluoride ions (11) was introduced. In vitro and preclinical animal studies showed a faster rate of bone formation around implants with fluoridated surface when compared to the same surface without fluoride ions (11) (12). There has been indications that utilization of these enhanced surfaces may improve implant success in patients with systemic conditions such as diabetes and osteoporosis, in compromised sites as well as for immediate or early loading protocol(8, 13).

The use of immediate loading protocols may offer several advantages when compared to a delayed loading approach including: shortened treatment period, improved function, reduced

chair time for provisional relining, improved patient acceptance and no need for a second surgical intervention. A recent systematic review reported similar implant success rate when immediate loading protocols are compared to a conventional approach (14) but also advocated the need for more data based on randomized control clinical trials to enhance the quality of the available evidence (15). Immediate loading using 2 or 4 implants splinted with a bar supporting mandibular overdentures has been validated and documented by case series and prospective studies (5). However, limited evidence exists based on randomized controlled clinical trials comparing 2 unsplinted implants supporting OVD with immediate loading versus conventional approach.

Locator™ (Zest Anchors, Escondido, CA, USA) is a self-aligning, dual retentive attachment available with different retention values (16). When compared to magnets and ball attachments, Locator™ show higher retention and stability (16). Despite use of Locator™ attachment is becoming popular among clinician, limited clinical data are available on this retention system. In particular, scarce data are available when Locator™ is used in combination with immediate loading of dental implants.

The aim of this single blind randomized control clinical trial was to evaluate clinically and radiographically the performance of 2 unsplinted fluoride-modified micro-rough titanium surface implants (OsseoSpeed™TX ,Astra-tech DENTSPLY Implants, Mölndal, Sweden) supporting a Locator™-retained mandibular overdenture, with either an immediate or a delayed loading protocol in a 12-month post surgical period.

Materials and Methods

The study was a single blind parallel arms randomized controlled clinical trial, whereby each patient received 2 implants supporting a mandibular OVD retained by Locator™ abutments. The patients were randomly assigned to either one of the following groups: Test group (IL) – the implants were immediately loaded, or Control group (DL) - the implants were submerged under mucosa and loaded after 3 months of healing.

The Institutional Review Board, at the University of Connecticut, approved the research protocol (IRB#10-305-3). Participants were recruited among patients with existing mandibular denture, who were seeking to have implant-retained OVD at the University of Connecticut Health Center, Graduate Periodontology Clinic, from October 2010 to December 2012.

An initial evaluation was conducted to determine whether the patient met the study inclusion criteria. Inclusion and exclusion criteria are summarized in Fig.1. This evaluation consisted of a medical history questionnaire, a clinical examination and a radiographic assessment. Orthopantomograms were obtained for all patients. In cases with severe bone resorption, a cone beam computerized tomography (CBCT) was taken. A preoperative prosthetic evaluation of the existing prostheses was performed by a certified prosthodontist (S.R). Based on the inclusion criteria, the dentures had to be in function for at least 4 months with adequate stability and occlusion. Once the patient was deemed eligible, the mandibular denture was duplicated and used as radiographic / surgical guide.

Visit schema and study timelines are reported in Fig.2.

Randomization and Allocation

Every patient was given a participant identification number. An independent investigator, not involved with patient treatment, generated the allocation list. Computer software was used to randomize the participant identification numbers into one of the two groups. This information was concealed in sealed opaque envelopes, which were opened after implants were placed. Neither the surgeon, nor the patient was aware of the group assignment until after implant insertion.

Surgical Procedure

The same experienced operator (GPS) performed all the surgeries. Two TX 4.0 S OsseoSpeed™ implants (DENTSPLY Implants, Mölndal, Sweden) were inserted in each participant under local anaesthesia obtained with lidocaine 2% with 1:100,000 epinephrine. Each participant received a prophylactic antibiotic regimen consisting of 2 grams of amoxicillin one hour prior to the surgical procedure. After a crestal incision, a full thickness flap was elevated. A vertical releasing incision at the facial midline aspect of the mandibular ridge was raised, if deemed necessary. The osteotomy sites were prepared following the drilling sequence provided by the manufacturer's surgical manual. To increase the implant primary stability, the implant site was underprepared in relation to bone quality(17). The 3.2 and 3.7 mm twist drills were used as the final drill for Class III –IV and I – II quality bone respectively (18). The implants were inserted in the canine /lateral incisor position following the surgical guide. During the implant insertion the maximum value of insertion torque (IT) was recorded. In case the IT was lower than 20 Ncm the implants were submerged, the patient was excluded from the study and the implant treatment

completed following the delayed protocol. For the DL group a cover screw was placed and the implants were submerged under the oral mucosa. For the IL group, Locator™ abutments were secured on the implant using hand torque and the flaps were sutured. Primary closure was achieved using 5-0 nylon (Monosoft; Syneture, Covidien, Mansfield, MA, USA) interrupted sutures. Patients of the DL group were not allowed to wear the denture for 14 days. Patients of the IL group had the denture connected immediately and were instructed not to remove the denture for 7 days (19). During 14-day post-surgical phase, the patients were asked not to brush the operated areas but to rinse with 0.12% chlorhexidine solution (Peridex; 3M ESPE, St Paul, MN, USA) twice a day, for one minute. Pain control was provided with 600 mg Ibuprofen as needed. Sutures were removed after two weeks.

Stage II Surgery: Implant Un-covery (DL Group Only) - Participants in the DL group were seen at 12 weeks for second stage surgery. After local anesthesia the crest was sounded to locate the cover screws. A crestal incision was made and a conservative full thickness flap elevation done. Cover screws were replaced with Locator™ abutments and the flaps secured with resorbable 5-0 chromic gut (Chromic gut; Perma Sharp, Hu-Friedy, Chicago, IL, USA) interrupted sutures.

Prosthetic Treatment

The Locator™ attachments were connected intraorally using cold curing resin (Super T; Amco, Philadelphia, PA, USA) following the manufacturer instructions (Zest Anchors, Escondido, CA, USA). The length of the Locator™ abutment was chosen based on the thickness of the peri-implant mucosa. No angled abutments were used. To avoid contact of the resin with the sutures and the surgical wound, a circular portion of sterile rubber dam sheet was adapted on the abutment during the pickup procedure (19). Occlusion and adaptation on the residual ridges was

then checked and adjusted if necessary and the patient dismissed. The blue (extra light retention) plastic insert patrix was used. No limitations to chewing function were given. In the IL group, the denture was immediately connected to the implants after surgery. In the DL group, the participants resumed the use of the denture in 2 weeks after implant placement. The dentures were used with soft reliner until the implants were uncovered. Implants uncovery and denture connection were performed in 12 weeks after implant placement.

Follow – Up Visits

Patients were recalled at 1, 2, 12, 24 and 52 weeks (±1week) after surgery. At the post-operative visits, occlusion, stability, and retention of the prostheses were evaluated and adjusted as required. At the 12 weeks visit the abutments were torqued at 25 Ncm using a torque wrench following manufacturer recommendations (Astra-tech DENTSPLY Implants, Mölndal, Sweden).

Radiographic Evaluation

Standardized periapical radiographs were taken at implant placement, at 6- and 12-month follow up visits using the paralleling technique and a customized Rinn® (Dentsply Rinn, Elgin, Illinois, USA) film holder. The film holder was indexed on the Locator™ attachment in order to allow for film position reproduction.

Primary and secondary outcomes

The primary dependent outcome variable used in the study was the radiographic bone level change (RBLC). The secondary outcome variables were: implant failure and prosthetic complications rate. Other independent variables recorded were: patient age, gender, plaque

control record (PCR), smoking status, restorative condition of the opposing arch, implant length, implant maximum insertion torque.

Radiographic Bone Level Change

Radiographic bone level change (RBLC) was measured on standardized periapical radiographs (Fig.3). A calibrated blinded examiner (A.D) made the measurements. Image analysis software (Image J, *v* 1.42., NIH, Bethesda, Maryland) was used to measure the distance between the implant platform and the most coronal bone level in contact with the implant surface. The first bone-to-implant contact at surgery was defined as baseline. The bone level at or coronal to the implant platform was considered as 0. The RBLC was calculated as the difference between the measurement at 1 year, at 6 months and the baseline value. Mesial and distal bone height measurements were averaged for each implant. The value of the average RBLC of the 2 implants for each participant was used for the analysis at patient level.

Implant failure criteria

Implants were considered as failed if at least one of the following condition was present: 1) implant mobility 2) radiolucency surrounding the implant,3) pain ,discomfort or ongoing pathologic process requiring implant removal (20). Implants were considered survived if in function at 12 months visit. The implant cumulative survival rate (CSR) was expressed as percentage of implants in function over the total number of implants placed.

Oral hygiene assessment

The oral hygiene was evaluated at 12-month visit. The Plaque Control Record (PCR) was used (21). The presence of plaque visible on the mesial, distal, buccal and lingual aspect of each

abutment was recorded. PCR was reported for each participant as the percentage of sites with plaque.

Prosthetic maintenance and complications

A record of the number of maintenance visits made in addition to the anticipated visit schema was documented for every patient. The reason for the extra-maintenance visit, nature of complaint and management measures were also recorded.

Maximum Insertion Torque

During the implant placement, IT was recorded during the seating of the most coronal implant threads by means of the surgical unit (W&H, Burmoos, Austria) and reported in the 20, 30, 40, 50 Ncm category. In case the torque to insert the implant was superior to the maximum value measurable with the surgical unit (50 Ncm) the hand wrench was used and the IT was recorded in the >50Ncm category. (20)

Statistical Analysis

A RBLC of 0.5 mm was considered to be of clinical relevance (22). Sample size analysis was calculated based on an α error of 5% and a power of 80%. A minimum sample size of 14 participants (28 implants) for each group was needed to detect a difference of 0.5 mm between the groups with a standard deviation of the change of 0.5 mm (Primer of Biostatistic 5.0, Statistical package). Considering 20% attrition, 18 participants per group were enrolled. Kolmogorov-Smirnov goodness of fit test was computed for the response variable to assess normal distribution. The patient was considered statistical unit. “Intent-to-treat” analysis was used. Parametric data were compared using Student-t test for independent groups and paired-t

test for intra group comparison. Non-parametric data were compared using Mann-Whitney Rank Sum test and Wilcoxon Signed Rank test for independent groups and intra group analysis respectively. Data relative to patient demographics, number of extra visits, prosthetic complications and implant failure rates were considered as nominal and presented with descriptive statistics. Nominal data were compared using a Chi-square analysis of contingency table. Correlations between IT and implant length to RBLC were evaluated using Spearman Rank Correlation test. The level of significance was set at 5% for all statistical tests.

Results

The patient flow and allocation during the study is reported in Fig.4. Thirty-two patients were consecutively treated. A summary of the patient population is presented in Tab.1. Four participants were smokers, 2 in the DL and 2 in the IL group, respectively. All the participants were wearing a complete denture in the maxillary arch with the exception of 2 participants in the DL group and 3 participants in the IL group. The participants in the DL group had natural dentition and implant supported fixed prosthesis respectively. The subjects in the IL group had implant supported OVD.

Since all patients completed the study, no clinical dropout occurred. All participants healed with minor discomfort. No swelling or surgical complications were reported. No premature exposure of implants was reported in the DL group. Sixty-four implants were placed. Two implants in 1 patient in the IL group did not reach IT of 20 Ncm at the time of placement. The implants were submerged ,the patient was treated with a delayed protocol and, hence, excluded from the study. No implants were lost in the DL group (0/30) for a CSR of 100%. In the IL group, 2 implants failed in one participant (2/30) resulting to a CSR of 94%. The difference in CSR between the

groups was not statistically significant (*p=0.5,* Chi-square). The failed implants were 13 mm long, inserted with >50 Ncm IT in a 70 years old man, non smoker, with history of previous implant failure. The implants were found mobile and were removed at 4- week visit. The patient refused to have the implants replaced and remained with his complete denture. As per "intent to treat" analysis, the data relative to the failed implants were included in the analysis for IT and implant length. A total of 15 participants and 30 implants per group were available for statistical analysis at the 12 months visit.

Radiographic bone level change

RBLC distribution at patient and implant level for DL and IL is reported in Table 2.

The intra-group comparison of RBLC from baseline to 6 months and from baseline to 1 year showed loss of marginal bone in both IL and DL group and the difference was statistically significant (Fig.5) RBLC from baseline to 6 months was 0.39 mm (±0.3) and 0.27 (±0.4) for DL and IL, respectively. The mean RBLC from baseline to 1 year was 0.54 (±0.5) mm and 0.25 (±0.5) mm for DL and IL, respectively.

Since the RBLC data for the IL group resulted non-normally distributed (*p<0.001,* Kolmogorov-Smirnov goodness of fit test), the median RBLC values between DL and IL were compared using Mann-Whitney Rank Sum test. Tab.3. A statistically significant difference was observed at 12-month interval (*p<0.02,* Mann-Whitney Rank Sum) with a smaller RBLC in the IL group.

Implant Length

Implant length distribution for DL and IL groups was reported in Tab.4. A statistically significant difference was observed for the implant length between DL and IL (*p= 0.034,* Mann-Whitney Rank Sum test), with shorter implants in the IL group. A Spearman Rank test was carried out to evaluate the effect of implant length on RBLC and no correlation was observed (DL; *r=0.6*, IL; *r=0.13*, Spearman Rank Correlation test)

Insertion Torque

IT distribution amongst DL and IL group is reported in Tab.5. No difference was observed for IT between DL and IL implants (*p=0.92*, Mann-Whitney Rank Sum test). Spearman Rank Correlation test was carried out to evaluate the RBLC in relation to IT and the correlation was not statistically significant (DL; *r=0.26*, IL; *r=0.65,* Spearman Rank Correlation test).

Plaque Control Record

The median PCR score 12 months after implant placement for IL and DL group was 43.75% and 37.5% (range 0-100%), respectively. No statistical difference was observed between the groups ($p<0.4$ *Mann-Whitney Rank Sum test*).

Prosthetic maintenance visit and complications

The number of extra maintenance visit is presented in Table 6. No statistically significant difference was observed between the groups (*p=0.7,1* Chi-square).

Discussion

With this single blind parallel arms randomized controlled clinical trial, we aimed to provide more evidence on the clinical and radiographic outcome of implants immediately loaded using a Locator™-retained mandibular OVD. The overall implant CSR was 97% one year after

surgical placement. No implant failure was reported in the DL group, whereas 2 implants failed in the IL group for a CSR of 94%.

The present CSR data are in agreement with previous investigations, which showed an overall CSR between 81 to 100% (23) (24) (25) (26) (27), In addition, a CSR similar to our results was reported in recent randomized controlled studies (28, 29) Although immediate loading may provide similar CSR when compared to delayed loading, a trend toward a higher implant failure has been reported with immediate loading, as indicated in a recent systematic review and meta-analysis (14).

The primary outcome variable used in this study was RBLC. RBLC is a generally accepted parameter to assess implant success (30) (31) (32) and bone response to occlusal loading (33). The mean RBLC reported in this study for the IL group was 0.25 mm±0.5 consistent with previous data obtained using fluoride-modified micro-rough titanium surface implants (34) (35). However, higher RBLC values were reported by others using immediate loading with different implant designs and surface configurations (19) (28, 29, 36) .When comparing the RBLC between IL and DL group, a statistically significant difference was observed with smaller change of marginal bone level recorded for the IL group. These results are consistent with our previous report and others (37). (38). Moreover, these observations have been further confirmed in a recent meta analysis reporting a statistically significant smaller RBLC on immediately loaded implants when compared to delayed loading (14). A biological explanation of the positive effect of loading improving the initial phase of bone healing has been showed in both *in-vitro* and *in-vivo* studies (39) (40) (41) (42). Qi et al (40) evaluated the response of mesenchymal stem cells to mechanical strain and their consequent gene expression patterns. Their results suggested

that mechanical strain might act as a stimulator to induce differentiation of stem cells into osteoblasts. Indeed, cyclic tensile strain has been shown to increase osteoprotegerin synthesis and decrease soluble receptor activator of nuclear factor kappa-B ligand (RANKL)(43), thus favoring bone formation. Duyck et al (44)tested this theory in a rabbit model and concluded mechanical loading stimulated bone formation and led to higher bone fraction.

Our findings are in conflict with a recent randomized controlled study comparing 2 unsplinted implants supporting a Locator™ retained mandibular OVD either loaded immediately or following conventional loading(29). The implants loaded immediately, presented significantly higher vertical bone loss when compared to the delayed loading group after 1 year of function. The difference between these outcomes and our results can in part be explained by the performance of the implant material utilized in our study. In particular, the combination of implant design and surface properties may have contributed to enhance the bone response under immediate loading condition. The OsseoSpeed™- TX implants features a switching platform connection. Several animal and human studies provide evidence that implant with switching platform connection showed significantly less RBLC (45). Also, the micro-threaded design in the most coronal aspect of the implant may justify the improved marginal bone response. (46) (47, 48). The fluoride-modified micro-rough implant surface of the implant used in this trial has showed to improved bone to implant contact both *in vitro* and in animal studies (11) (12). In particular, bone deposition seems to be accelerated during the early stage of bone healing when compared to a traditional sandblasted surface (49). Though, the enhanced early bone formation may have contributed to the small RBLC and to the marginal bone level stability observed both in the DL and IL group.

Implant primary stability has been considered a very important factor when immediate loading is applied (15). Since IT value correlated with implant primary stability (50) (51-53), , we used this parameter to quantify implant primary stability and bone quality at time of insertion. Also, we used the under-preparation of the osteotomy site as meaning to increase the IT value (17).. Although some authors have raised concerns on the use of high IT as possible cause of compression necrosis of the bone (54) (55), animal and human studies have showed no detrimental effect of high IT (>50 Ncm) on peri-implant bone healing (56) (20) (57) (51).

The lower limit of IT to allow immediate loading of implants has not yet been determined. Ottoni et al. suggested an IT of ≥32 Ncm (58). Norton et al (59), reported a 100% CSR of implants immediately placed and loaded with single crowns in the aesthetic zone using a IT <25 Ncm. In our study the IT value between the groups was similar. The lower IT value used for IL was 20 Ncm. About 38% (12/32) of the implants in the IL group were placed with ≤30 Ncm IT and none of the implants placed with this IT value were lost. Furthermore, no correlation between IT values and loss of marginal bone was observed.

Implant length has been considered critical factor for the success of immediate loading protocols as it may be associated with higher primary stability (60). Several studies recommended implant length of at least 13 or 15 mm (34, 36, 50) when immediate loading of unsplinted implants is performed. In the present investigation we used implants 8 mm or longer with a diameter of 4 mm. In addition, the IL group had shorter implant when compared to the DL group. Fifty percent of implants placed in the IL group were <13 mm long and none were lost during the observation period. Hence, our findings do not seem to support the use of long

implants to increase clinical success with immediate loading protocols as the length did not correlate with RBLC 12 months after placement.

Loading forces may play a role in determining the different response on RBLC around dental implants. A factor that need to be discussed in relation to occlusal forces, is the presence, in our study population, of participants presenting opposing occlusion with either natural dentition or implant supported prosthesis. The detrimental effect of antagonist natural teeth or implant supported prosthesis on survival /success of implants retaining an opposing mandibular OVD, has never been demonstrated (61). Therefore, the presence of implant supported prosthesis or natural dentition in the maxillary arch was not an exclusion criteria in our investigation. Nevertheless, to control for the heterogeneity of our sample, we run a sub-group analysis including only participants wearing complete maxillary dentures and the statistically significant difference of RBLC between the groups was still confirmed ($p<0.02$-data not shown).

To optimize the clinical performance of implant supported OVD, the prosthesis should have adequate soft tissue support and stable occlusion (62, 63) (19). Each mandibular denture in the present investigation was evaluated prior to entering the trial. Adequate soft tissue support and stable occlusion were required inclusion criteria. One of the limitations of our study was that dentures were fabricated with different techniques by outside providers. This may explain the higher number of extra visit for adjustments reported in this study when compared to others (34). However, when evaluating the number of maintenance visits between the IL and DL group, no difference was observed. Previous reports indicated that maintenance needs for implant supported OVD were higher during the first year of function (64). Main reasons for maintenance

appointments were denture adjustment and patrix/matrix repair or replacement (64). This is consistent with our observation. In fact, the most common reason for extra-visit appointment in our study were denture adjustments followed by patrix replacement. It can be speculated that the utilization of a standardized technique for the fabrication of the prosthesis could have reduced the number of maintenance appointments. Nevertheless, the use of dentures fabricated with different methodologies may provide evidence for a more generalized applicability of the immediate loading approach utilized in the present study.

Conclusions

Within the limits of the present trial, it can be concluded that:

1) Immediate loading of 2 unsplinted fluoride-modified micro-rough titanium surface implants supporting Locator™ retained mandibular OVD seems to be a suitable alternative treatment option.

2) A significantly smaller RBLC after 1 year of loading was observed on IL implants when compared to implants placed with conventional protocol

3) Neither implant length nor IT values seemed have an effect on RBLC, 12 months after surgical placement.

Further investigations are needed to confirm these results.

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Fig. 1:

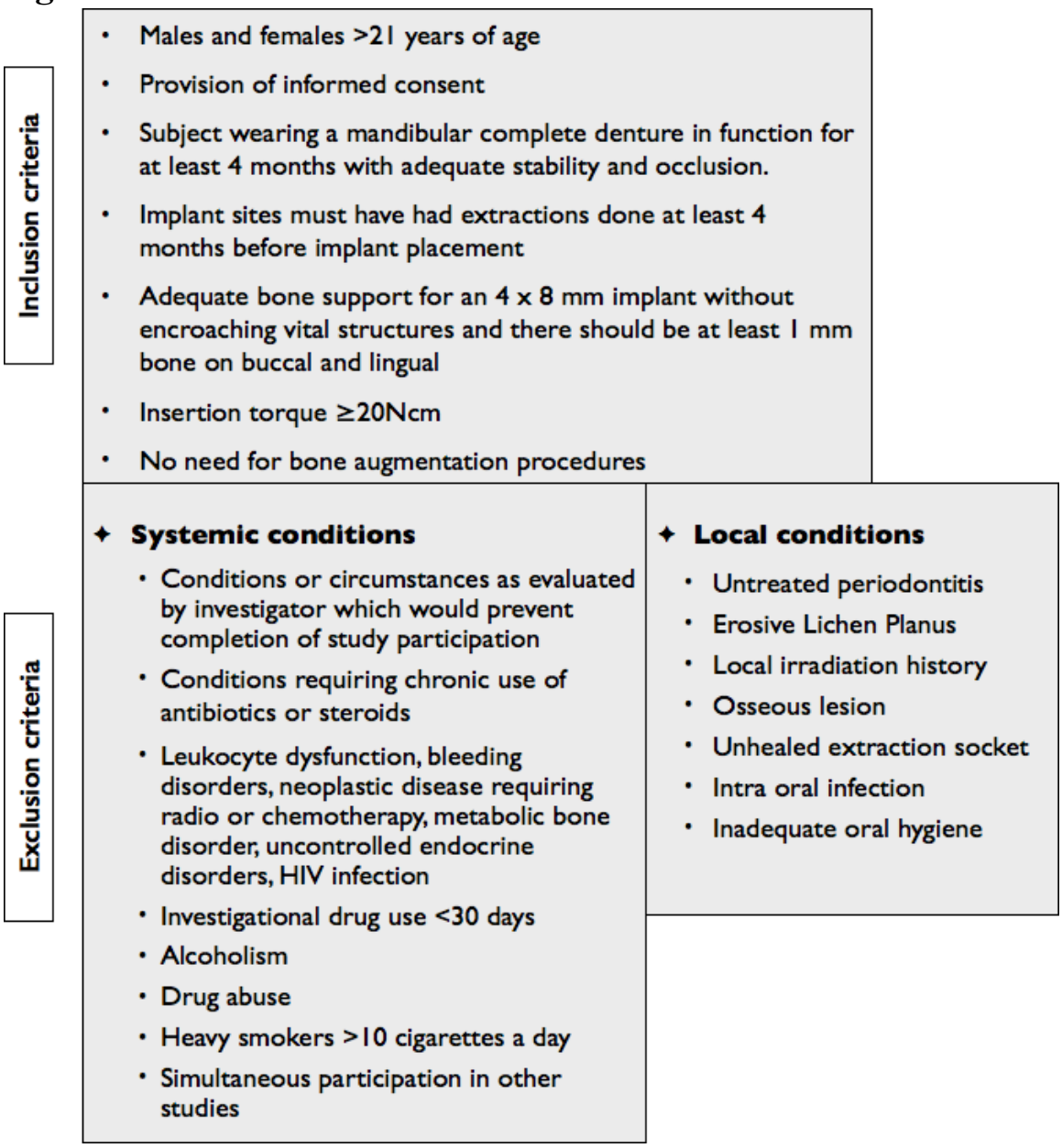
Inclusion criteria
Males and females >21 years of age
Provision of informed consent
Subject wearing a mandibular complete denture in function for at least 4 months with adequate stability and occlusion.
Implant sites must have had extractions done at least 4 months before implant placement
Adequate bone support for an 4 x 8 mm implant without encroaching vital structures and there should be at least 1 mm bone on buccal and lingual
Insertion torque ≥20Ncm
No need for bone augmentation procedures
Exclusion criteria
Systemic conditions
Conditions or circumstances as evaluated by investigator which would prevent completion of study participation
Conditions requiring chronic use of antibiotics or steroids
Leukocyte dysfunction, bleeding disorders, neoplastic disease requiring radio or chemotherapy, metabolic bone disorder, uncontrolled endocrine disorders, HIV infection
Investigational drug use <30 days
Alcoholism
Drug abuse
Heavy smokers >10 cigarettes a day
Simultaneous participation in other studies
Local conditions
Untreated periodontitis
Erosive Lichen Planus
Local irradiation history
Osseous lesion
Unhealed extraction socket
Intra oral infection
Inadequate oral hygiene

Fig. 2:

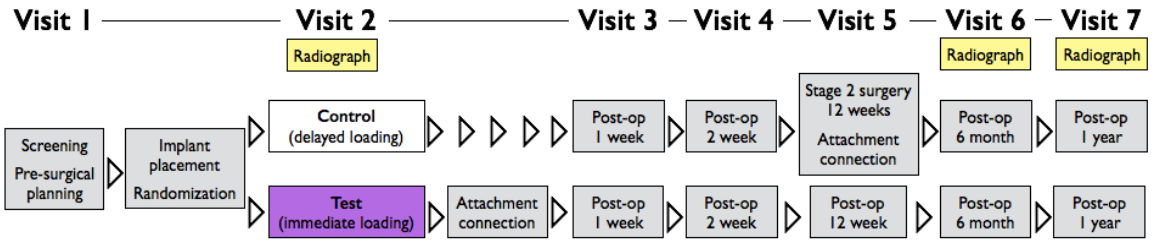
Visit 1
Visit 2
Visit 3
Visit 4
Visit 5
Visit 6
Visit 7
Radiograph
Radiograph
Radiograph
Screening
Pre-surgical planning
Implant placement
Randomization
Control
(delayed loading)
Test
(immediate loading)
Attachment connection
Post-op 1 week
Post-op 2 week
Stage 2 surgery 12 weeks
Attachment connection
Post-op 12 week
Post-op 6 month
Post-op 1 year

Fig. 3:

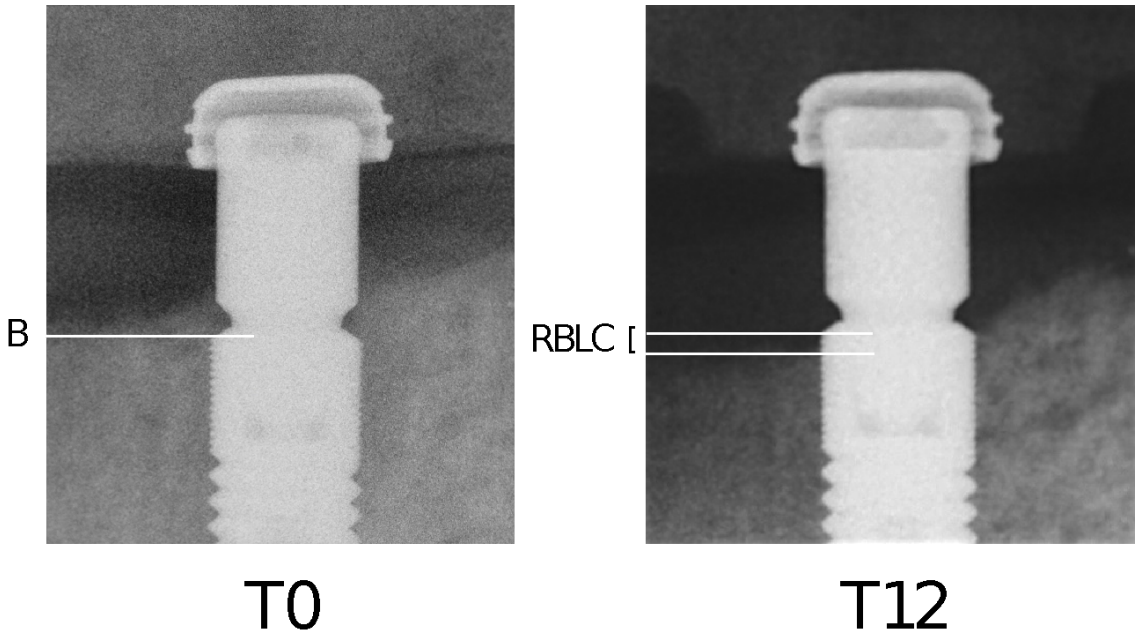

Fig. 4:

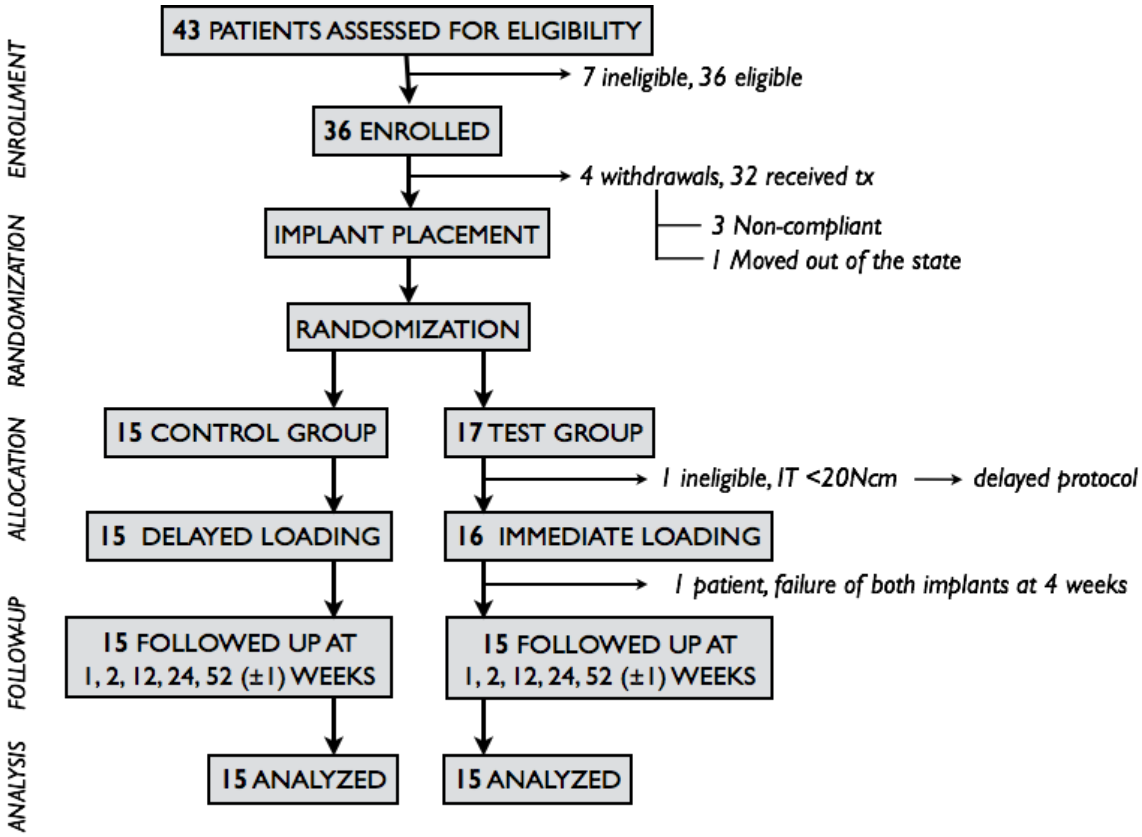
ENROLLMENT
RANDOMIZATION
ALLOCATION
FOLLOW-UP
ANALYSIS
43 PATIENTS ASSESSED FOR ELIGIBILITY
7 ineligible, 36 eligible
36 ENROLLED
4 withdrawals, 32 received tx
3 Non-compliant
1 Moved out of the state
IMPLANT PLACEMENT
RANDOMIZATION
15 CONTROL GROUP
17 TEST GROUP
1 ineligible, IT <20Ncm
delayed protocol
15 DELAYED LOADING
16 IMMEDIATE LOADING
1 patient, failure of both implants at 4 weeks
15 FOLLOWED UP AT 1, 2, 12, 24, 52 (±1) WEEKS
15 FOLLOWED UP AT 1, 2, 12, 24, 52 (±1) WEEKS
15 ANALYZED
15 ANALYZED

Fig. 5:

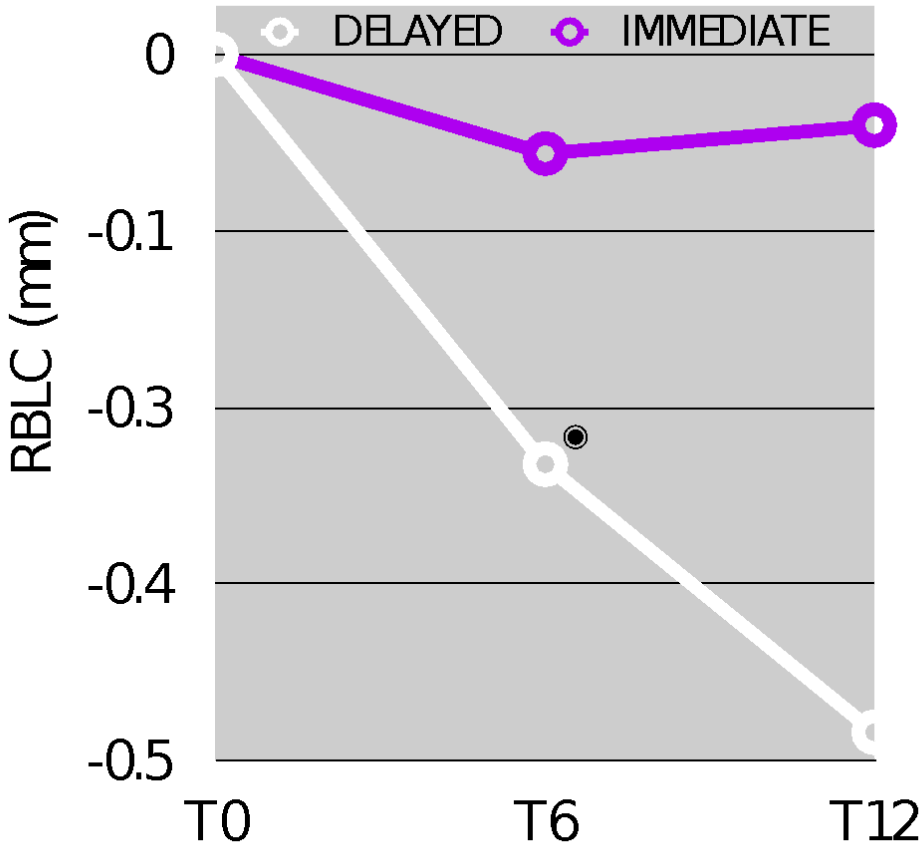

Table 1. Demographic Characteristics of Treatment Groups

	Age		Gender		Smoking Status		Opposing Arch		
	Mean (SD)	Range	Male	Female	Smoking	Non-smoking	Complete Denture	Dentate	Implant supported prosthesis
DL (n=15)	66.2 (8.6)	57-85	10	5	2	13	13	1	1
IL (n=17)	66.6 (10.2)	53-79	10	7	2	15	14	0	3
Total (n=32)	66.4 (9.3)	53-85	20	12	4	28	27	1	4

Table 2 . Distribution of Radiographic Bone Level Change (RBLC)						
Implant level						
RBLC (mm)	< 0.5	0.5 - 1	<1 - 1.5	<1.5 - 2	< 2 - 2.5	>2.5
DL n. of patients (%) (n=30)	17 (57%)	9 (30%)	2 (7%)	1 (3%)	0	1 (3%)
IL n. of patients (%) (n=30)	26 (87%)	3 (10%)	0	0	0	1 (3%)
Patient level						
RBLC (mm)	< 0.5	0.5 - 1	<1 - 1.5	<1.5 - 2	< 2 - 2.5	>2.5
DL n. of patients (%) (n=15)	8 (53%)	6 (40%)	0	0	1(7%)	0
IL n. of patients (%) (n=15)	13 (87%)	1 (6.5%)	0	0	1(6.5%)	0

Table 3. Radiographic Bone Level Change (RBLC)

Between Group Analysis at Patient Level

RBLC	DL Median (Range)	IL Median (range)	P value (Mann-Whitney U test)
Δ T6-T0 6 months	0.29 (0-.9) n=15	0.07 mm (0-1.7) n=15	0.1
Δ T12-T0 12 months	0.48 mm (0-2.19) n=15	0.05 mm (0-2.18) n=15	0.019

Table 4. Implant Length Distribution				
Implant length	8mm	11mm	13mm	15mm
DL n. of implants (%) (n=30)	0	10 (33.5%)	14 (46.5%)	6 (20%)
IL n. of implants (%) (n=32)	2 (2%)	14 (48%)	16 (50%)	0

Mann Whiteny Rank Sum test (*p=0.034*):

Table 5. Insertion Torque Distribution					
Peak IT (Ncm)	20	30	40	50	>50
DL n. of implants (%) (n=30)	3 (10%)	6 (20%)	11 (37%)	4 (13%)	6 (20%)
IL n. of implants (%) (n=32)	5 (15%)	7 (22%)	5 (15%)	6 (19%)	9 (28%)

Mann Whiteny Rank Sum test (level of significance: $p = 0.92$)

Table 6. Prosthetic Complication and Maintenance Visits		
	DL	IL
Denture fracture	2	2
Insert change	4	3
Abutment loosening	2	2
Denture adjustment	10	14
TOTAL	18	21

Chi Square test (level of significance :$p = 0.488$).

Legend for figures

Figure 1: Inclusion and exclusion criteria.

Figure 2: Visit schema and study timelines.

Figure 3: Radiographs at baseline (T0) and at 12 months (T12). The first bone-to-implant contact at surgery was defined as baseline (B). The bone level at or coronal to the implant platform was considered as 0. RBLC was measured as the distance between the implant platform and the most coronal level of the bone deemed to be in contact with the implant surface at T12. (Δ = T12- T0).

Figure 4: Patient flow and allocation.

Figure 5: Intragroup comparison of Radiographic Bone Level Change (RBLC):
DL; 0-6m ($p<0.001^{\bullet}$), 0-12m ($p<0.02^{\diamond}$), 6-12m ($p<0.08$) Paired T test,
IL: 0-6m ($p<0.01^{*}$), 0-12m ($p<0.01^{\star}$), 6-12m ($p<1.0$) Wilcoxon Singed Rank test