Survival and Success Rates of Short Straumann Implants Placed in the Mandible: A Retrospective Study with up to 5 Year Follow-Up

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Abstract: ***Aims***: The purpose of this retrospective, non-interventional, open cohort study is to report on short implants (8 mm's and less) as used to treat severe atrophic ridges in absence of bone graft.

Materials and Methods: Retrospectively all Straumann implant implants of length 6 and 8 mm that were placed in the posterior mandible with no bone graft were evaluated (N= 720). Implant restorations were all splinted together. Bone levels were evaluated at 12 months then at 1-2 year intervals up to 5 years.

Results: Among the 720 implants placed, the overall 5-year survival rate was 100%. The overall cumulative success rate of all implants was 95.8% at 3 years and 93.4% at 5 years, respectively. Success rates of the 6 mm implants were 92.3% and 90.5% at 3 and 5 years, respectively. Success rates for the 8 mm implants were found to be 97.2% and 94.6% at 3 and 5 years, respectively. There was no statistically significant difference in the success rates of 6 and 8 mm implants.

Conclustion: Short multiple splinted implants are an effective treatment modality in the resorbed mandible and may provide alternative to bone grafting or nerve transposition.

Keywords: ~~Please provide missing keywords.~~ Short implant, mandible, survival, success, retrospective, non-grafted

1. INTRODUCTION

The atrophic mandibular posterior ridge has traditionally been an area that is difficult to restore with dental implants [1, 2]. Historically a ridge height over the mandibular nerve of about 13 mm was required in order to place a "standard" 10 mm implant so as to allow for a 1.5 mm over drill and a 1.5 mm safety margin for error since in the case of machined implants less than 10 mm's in height had greater failure rates [2,3]. A posterior ridge that has had long-term atrophy would often be untreatable, using this 13 mm height threshold. Subsequently a number of bone grafting options have been developed for vertical bone augmentation. Success and durability with vertical augmentation, however, is uncertain and it increases the cost of treatment and the rate of complications significantly [1,2]. A review on horizontal and vertical bone augmentation techniques concluded that short implants might provide a better alternative than vertical bone grafting [2,4].

The success rate for short implants, although initially controversial, has recently been established as a viable treatment option by a number of articles and has opened opportunities to treat a variety of atrophic ridges without the need for augmentation [2, 5, 6]. This may be due to the fact that implants with a roughened surface provide more bone to implant contact ratio compared than machined implant designs and so a short implant may offer comparable implant bone stability to longer machined implants. This concept has been reinforced by several biomechanical studies suggesting that maximum bone stress is independent of implant length and even that implant width is more important than the additional length for optimizing loading stress distribution [5, 7].

Splinting implants was initially indicated in areas of load risk such as the posterior mandible and maxilla [8]. It is possible that short implants may be at risk for overload therefore splinting short implants may be advisable in the edentulous posterior region. Additionally, studies have demonstrated that during functional loading, there is more favourable strain distribution when splinting short implants [6, 9, 10].

Shorter clearances over the nerve may be considered. Compared to original implant systems where the overdrill distance is about 1.5 mm, the Straumann™ drills have an overdrill of 0.4 mm. Furthermore, with clear concise drill markings and radiographic indicators matching each implant size the osteotomy depth can be evaluated readily. The use of pre-treatment computed tomography and the use of intraoral digital radiographs with indicators at time of surgery allows

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real-time evaluation of depths so may allow implant placement closer to the nerve than the conventionally recommended 3mm clearance from the superior border of the inferior alveolar nerve canal [6, 9, 11].

The purpose of this paper was to retrospectively assess the survival and success rates of short Straumann implants (8 mm and 6mm) in atrophic mandible without added bone graft.

2. MATERIALS AND METHODS

This retrospective observational study consisted of 720 short (6 and 8 mm) Straumann implant fixtures in posterior mandibular sextants. The posterior mandible was defined as FDI sites 4-5-6-7-8, which included both bicuspids and all three molar sites. Exclusion criteria were implants in the anterior positions, implants of length greater than 8 mm and bone grafting done simultaneous or prior to implant placement in the same area. The implants were placed between 01/03/1999 throughout 01/03/2012 at a private periodontal practise in Calgary Alberta, Canada with all surgeries completed by a single Periodontist (DF) and restored by a variety of general dentists and prosthodontists. The clinician placing the implants (DF) took and recorded all measurements. There were no patient-based exclusion criteria other than ASA (American Society of Anesthesiology Physical Status Classification System) class 3 or higher [12,13].

Informed consent to implant surgery was obtained from all patients. Where applicable all patients were advised of proximity of mandibular canal and the risk for parasthesia. The Clinical Research Board of the University of British Columbia approved the study. All implants were placed and prosthetic components used according to the manufacturer's instructions including a pre-treatment rinse and facial scrub with 0.12% Chlorhexidine, a draped field and sterile saline irrigation. The patients were conscious during the procedures and were given local anesthetic (typically Marcaine 2% 1:200,000 epinephrine) with the option of a mild oral sedative (1 mg Ativan or 0.25 mg Halcion). Patients were typically given 2 grams of amoxicillin 1 hour preoperatively with a single post opt dose of 500 mg of Amoxicillin. Additional post-operative antibiotic regimen (Amoxicillin 250 mg, three times a day for 7 days) was then used only if immediate socket placement was performed. Patients allergic to penicillin were typically given Clindamycin 600 mg, 1 hour preoperatively. A full thickness flap was elevated and the mandibular foramen visualized, the ridge was usually leveled to remove knife edge crest then a 2.2 mm twist drill was used to about 80% of planned length then an periapical radiograph taken to asses proximity to nerve. Then standard drilling protocols per manufacturers guidelines. Straumann drills, implants and prosthetic components including abutments were used and intraoperative radiographs taken with respective indicators after osteotomy width increase. The use of pre-treatment computed tomography and the use of intraoral indicators allowed real-time evaluation of depths so our planned apical clearance was as low as 1mm versus the conventionally recommended 3mm clearance from the superior border of the inferior alveolar nerve canal

Surgical protocols varied from immediate placement in extraction sockets to placement in the mature ridge. All implants were placed using open flap surgery with the only exception being implants placed in the fresh extraction socket, which was done flapless. Immediate implants were sized so as to have bone to implant gap <2mm and so were placed without bone graft. Implant loading protocol varied according to individual case requirements, but was separated into 2 categories; immediate (within 48 hours of placement) and conventional loading (2 to 4 months after placement) or delayed (6 months after placement).

Post-operative medication was typically an NSAID for 3 or more days unless contraindicated. When possible patients were contacted within 24 hours by phone for post op complications and also seen at about 1 week for post op examination, where untoward events of infection, pain or parasthesia were recorded. In the event of parasthesia reported after 24 hours then the implant was reversed about 0.5mm. The patients were evaluated at 2-3 month post implant insertion and implants were load tested to 35 N/cm forward torque test to ensure integration. Radiographic bone levels were also measured at this time point to establish a baseline crestal bone level (CBL). An implant was deemed initially "survived" if it was functionally inserted, non-mobile and passed the torque test 2-3 months after placement. Subsequent follow up was generally scheduled on 1, 3, and 5 year intervals but considering the nature of this open-cohort study the patients were seen at various time points and not all patients returned for follow up. Subsequent to 5 years the follow up was less defined with patients either returning because they were patients with large and complex multi unit prosthesis or patients needing more implants sites or patients with a potential concern noted by the referring dentists.

Several Straumann implant types were used, including Standard (S) and Standard Plus (SP), Bone Level (BL) and Tapered Effect (TE) implants. The vast majority of implant surface used was SLA™ with smaller numbers of the hydrophilic SLActive™ surface.

The main outcome variables in the analysis are "time to implant failure" and bone loss over time as measured from the smooth rough interface. Failure was defined as the removal of the implant for any reason. Crestal bone level (CBL) was measured on standardized periapical radiograph using the DEXIS (Pennsylvania, USA) radiograph software program was used to measure CBL relative to the smooth/rough interface, i.e.: beyond the 2.8 or 1.8 mm collar on Straumann implants. All bone loss measurements were taken from the coronal aspect of the implant shoulder to the lowest coronal aspect of the alveolar crest, regardless of mesial or distal position thus measuring the side with the greatest bone loss. A threshold of 1 mm bone loss was used to determine implant "success" in the present study and this was chosen as a critical threshold for calculation of bone loss and thereby exposed rough surface. The 1 mm bone loss criterion to determine implant success comes from guidelines recently provided by Sanz & Chapple [14].

Implant survival and success were analyzed using a life table analysis as a function of time. We applied Fisher's exact test to test the relationship between categorical variables such as implant height (6 mm/8 mm) and success (yes/no). The Kaplan Meier analysis and Log Rank test were used to analyze the equality of success functions. The significance level was 5% using the R software statistical package.

3. RESULTS

3.1. Implant Types and Sites

A total of 322 mandibular posterior partially edentulous patients had 720 short 6 and 8 mm Straumann implants placed and followed up to 5 years. The mean age of the patients was 60.3 years. The implants were all placed in the posterior mandible (Figure **1**). 516 (71.6%) of the implants were 8 mm and 204 (28.4%) were 6 mm long (Table **1**). All implants were restored with splinted restorations. Thirty implants were placed immediately after extraction two of which were immediately loaded. There was immediate loading of 7 other implants placed in the healed site. The other 711 implants were loaded conventionally (after at least 3 months of healing).

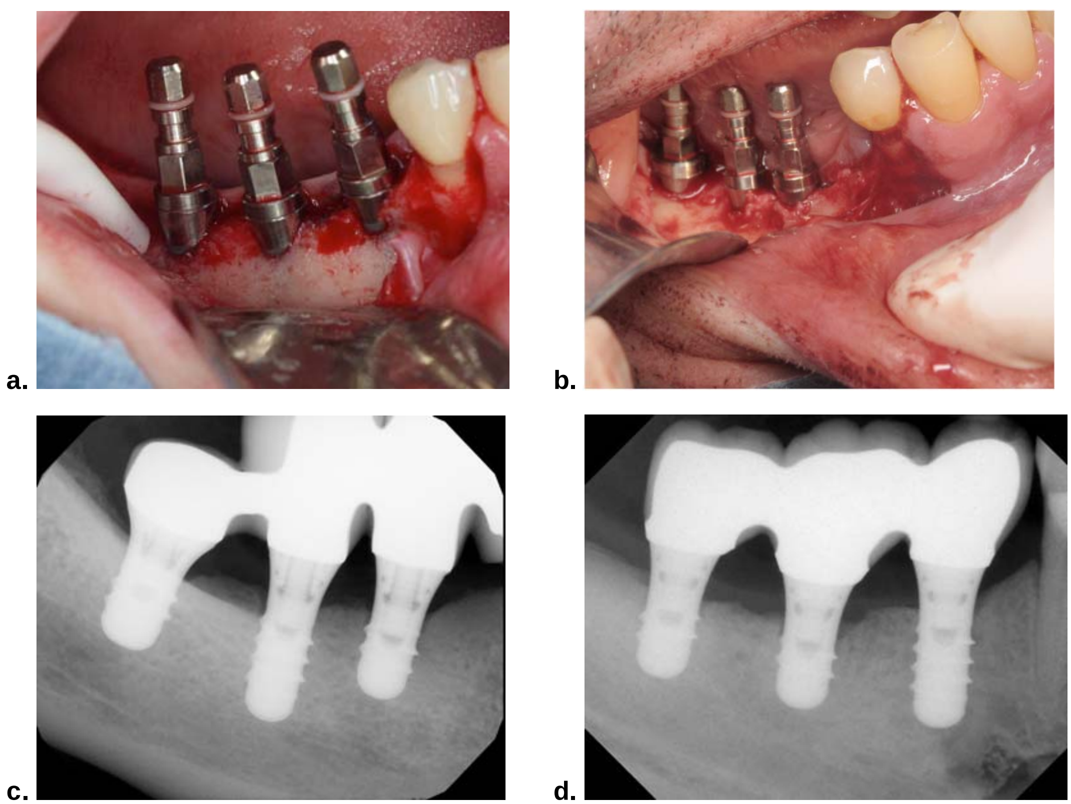

Figure 1: Short implants placed in the posterior mandible. 4.1. **a**. and 4.1.**b**. Surgical site preparation for three implants. 4.1.**c**. and 4.1.**d**. Periapical radiograph of 3 short implants placed and splinted.

Table 1: Descriptive Analysis of Data Set

Total Number of Patients	322
Mean Age	60.3
Age Range	40-83
Total number of implants placed	720
Number 6 mm implants placed	204 (28.4%)
Total number 8 mm implants	516 (71.6%)
Immediately placed	30 (0.04%)
Immediately loaded	9 (0.01%)

3.2. Implant Survival and Success Rates

Among the 720 implants placed, there were no recorded failures for an overall 5-year survival rate of 100%.

Success rates were evaluated using a threshold of 1 mm total bone loss. The overall cumulative success rate of all implants was 95.8% at 3 years and 93.4% at 5 years, respectively (Figure **2**, Table **2**). Success rates of the 6 mm implants were 92.3% and 90.5% at 3 and 5 years, respectively (Figure **3**, Table **3**). Success rates for the 8 mm implants were found to be 97.2% and 94.6% at 3 and 5 years, respectively (Figure **3**, Table **4**).

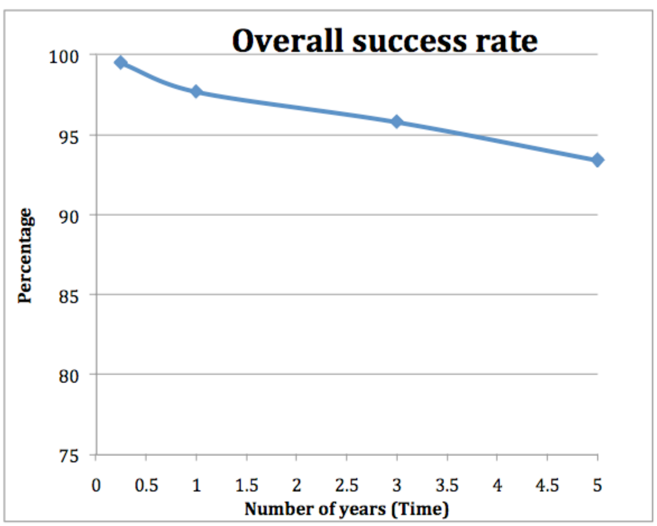

Figure 2: Kaplan Meier Curve for the overall success rate of all implants placed and followed-up for up to 5 years.

There was no statistically significant difference in the success rates of 6 and 8 mm implants. The success rates of the 30 immediate implants was 100% and the 9 immediately loaded was 100% at 3 and 5 years, respectively.

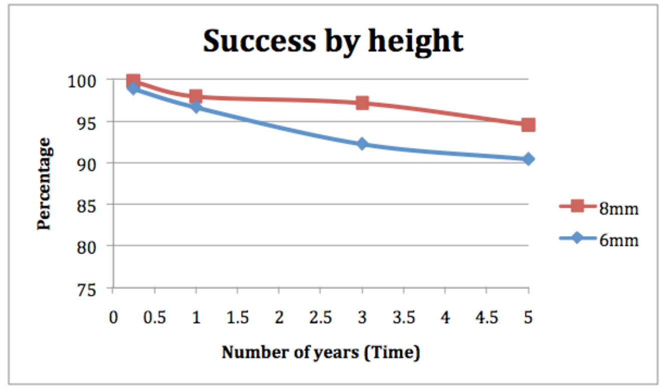

Figure 3: Kaplan Meier Curve comparing the success rates of 6 mm and 8 mm implants followed up to up to 5 years, using 1mm bone loss as threshold.

3.3 Post-Surgical Complications

In the present study, we recorded the incidence of post-surgical infection. In the 720 implants placed there were 3 cases of post-surgical infection, which were treated successfully with antibiotics and debridement, which represents 0.4% infection rate. There were no cases of permanent parasthesia and only 3 cases of short-term parasthesia < 1month.

3.4. Insertion Torque

53 implants were placed with an insertion torque of less than 20 N/cm. The success rate of implants placed with low and high torque was 95.8% and 92.2% at 5 years, respectively. There was no significant difference between the two groups (Figure **4**).

4. DISCUSSION

Avoiding complex grafting procedures in the mandible for conventional implant placement by placing

Table 2: Life Table for Overall Success Rate of all Short IMPLANTS

Time	Total Number	Unsuccessful	Percent Success	Standard Error	Lower 95% CI	Higher 95% CI
3 months	645	3	99.5	0.00268	0.990	1.000
1-2 years	478	9	97.7	0.00672	0.964	0.990
2-3 years	313	6	95.8	0.01004	0.938	0.978
4-5 years	163	4	93.4	0.01519	0.905	0.965

Table 3: Life Table for the Success Rate of all 6 mm Short Implants

Time	Total Number	Unsuccessful	Percent Success	Standard Error	Lower 95% CI	Higher 95% CI
3 months	179	2	98.9	0.00786	0.974	1.000
1-2 years	136	3	96.7	0.01463	0.939	0.996
2-3 years	88	4	92.3	0.02562	0.874	0.975
4-5 years	50	1	90.5	0.03105	0.846	0.968

Table 4: Life Table for the Success Rate of all 8 mm Short Implants

Time	Total Number	Unsuccessful	Percent Success	Standard Error	Lower 95% CI	Higher 95% CI
3 months	466	1	99.8	0.00214	0.994	1.000
1-2 years	342	6	98.0	0.00739	0.966	0.995
2-3 years	225	2	97.2	0.00955	0.953	0.991
4-5 years	113	3	94.6	0.01739	0.912	0.981

short implants is of benefit for the patient. These additional surgical procedures are a greater financial burden and increase the risk of complications and patient morbidity. Previously short implants were considered to be less reliable that the conventional

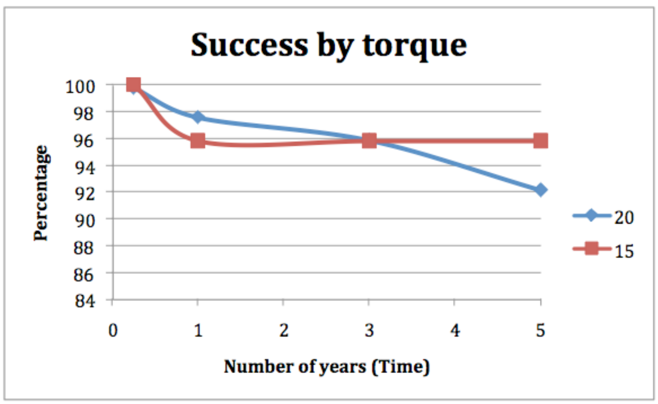

Figure 4: Kaplan Meier Curve comparing the success rate of implants placed in low torque (15N/cm or less) compared to implants placed in high insertion torque (20N/cm or more) followed up for up to 5 years.

counterparts [6,12,15]. However, recent studies have found highly successful results for short implants, most likely due to changes in implant design and surface characteristics [6, 16, 17]. All the implants used in this study were Straumann 6 and 8 mm implants that were splinted with fixed prostheses. A meta-analysis with a minimum of 12 months follow-up revealed mean survival rates of short implants 6 mm Straumann implants to be 98.6% [15,18]. Similar findings were found in another meta-analysis of short implants less than 8.5 mm in length with 1 to 5 year follow up and found that the cumulative survival rate for short implants of varying lengths was greater than 95% [16-18]. In both reviews, the majority of short implants that failed did so before loading. Two separate reviews found that short implants had an estimated 1-year cumulative survival rate of 97.9%, and an estimated 14-year cumulative survival rate of 88.1%, whereas conventional length implants had a survival rate of 86.7% at 14 years, showing no statistically significant difference between both groups [17-20]. These systematic reviews provide evidence, which support the findings in our study, of a cumulative survival rate of 100% up to 5 years, that short dental implants are a valid treatment option in the atrophic ridge.

Similar to the high survival rates found in this and previous studies, high success rates have also been implicated with short implants. Using the 1 mm crestal bone loss threshold, also used in the present study as the limit for success, a study of 7 mm implants place in the mandible found one-year success rate of 97.8% for short implants [17, 18, 21]. In a review of over 6000 short implants with 3458 placed in the posterior mandible a pooled success rate was 98.8% with a mean of 3.2 year follow up using Albrektsson's success criteria [6, 17].

All implants in the current study were splinted, which could have positively influenced the high survival and success rates of short implants. Marginal bone loss due to biological complications has been seen in many studies however, the role of occlusion and occlusal load is also considered to play a part in marginal bone remodelling [17, 22]. Although the review by Annibali *et al*. [6] indicates that splinting of short implants is not a requirement for success, Bergkvist *et al*. [16], using finite elemental analysis found that splinting implants reduced the stress levels in bone tissue around the implants by a factor of 9 compared to stress levels around non-splinted implant [6, 16, 17, 22]. In another study by Mendoca *et al*. [24] comparing splinted and non-splinted implants, splinted implants tended to be more successful although no significant difference was found between the two groups [22-24].

Insertion torque values did not seem to influence the survival or success rates of the implants placed in the present study. Opposite results have been noticed previously in a study that showed 86% cumulative survival rate of implants placed in less that 20 N/cm torque compared to 96% in implants placed with a torque of 30 N/cm or higher [22, 25, 26]. In the above study, however "spinner" implants were removed at the time of implant placement and counted towards the not-survived implants immediately reducing the survival rate of the low insertion torque group. The lack of a difference in success rates between the high and low insertion torques, in our study, could be due to several reasons. For example, in the present study, all implants were placed in the posterior mandible, which is known to have better success rates than implants placed in the maxilla [22, 27, 28]. Also, all implants used, had a rough surface. Surface roughness is believed to positively influence bone to implant contact ratio and implant healing by promoting favorable cellular responses [23, 25, 27, 28]. All implants were placed by the same experienced clinician who followed the same surgical protocol for all implants, possibly positively influencing the survival and success rates of the implants in this study [15, 25, 27, 28].

Post-operative infection rates are typically around 2.1% [22, 29, 30]. In the present study, the infection rate was only 0.04%. This may be explained by the lack of graft material acting as a foreign object, which may have been a factor in the low infection rate and low incidence of post-operative complications in the present study. In this study, a single dose of antibiotics was given 1 hour prior to the implant procedure. Furthermore since reports of increased complications exist in penicillin allergic patients, we arranged for penicillin allergy testing and in most cases this allowed the use of amoxicillin, which may be a factor in reducing our infection rate. Some studies have suggested that a single dose of antibiotics given 1 hour pre-operatively reduces the odds of dental implant failure by as high as 66.9% [15, 25, 31, 32]. Pre-operative antibiotics were not, however found to reduce the incidence of infection [15, 29, 30, 32]. Therefore, prophylactic antibiotic use may have only positively influenced the survival rate of the implants in our study and not have influenced the postoperative infection rate. The use of chlorhexidine rinse as part of a post-operative home care regimen could have positively influenced the low infection rate as seen by Powell *et al*. [30, 31, 33]. The low parasthesia rate with no permanent case and only 3 short term cases of parasthesia suggests that a reduced apical safety zone of 1mm when used with procedures as outlined in methods section and as used in this study may allow skilled clinicians to use short implants in more atrophic mandibles than has hitherto been advised.

Although few studies report on success rates rather than survival rates in the literature on immediate implants. According to a review by Ortega-Martinez *et al*. [34], short-term clinical results of immediate implants were comparable to those obtained with delayed implant placement [15, 34]**.** A recent review also failed to find a difference in success rates between immediately loaded and conventionally loaded implants [15, 35]. Although the number of immediately placed and immediately loaded implants were low compared to the entire data set the results are in accordance with recent literature that by choosing the appropriate case, immediate implants and immediate load results in survival and success rates that are equal to the conventionally placed and loaded implants

5. CONCLUSION

The findings of this retrospective study of 720 short splinted Straumann implants demonstrated high survival rates that are comparable to conventional length implants. Furthermore, short implants had high success rates that are comparable to conventional length implants indicating they are not more prone to bone loss over time. There were few complications and no case of permanent parasthesia despite the use of a reduced safety zone of only 1mm over mandibular nerve when using Straumann drills and intraoperative radiographic verification. Insertion torque values do not seem to play a role in the long-term survival or success rates of short implants when used as multiple splinted implants. The protocol in this study was that short implants were splinted based on theoretical biomechanical advantage of splinting on short implants in posterior locations but additional comparative studies of both short splinted and short non-splinted is required to assess whether or not splinting positively influences success or survival of implants. The low post-operative infection rate in this study compared to published rates of 2%, may in part be due to pre-operative antibiotics and also the lack of bone grafting required for short implants. We report promising results for short implants immediately placed and immediately loaded in limited cases with favourable bony support and insertion torque ≥ 30 Ncm. Though this was a very small subset so studies with greater number of cases are required for a conclusion on immediate placement with immediate loading of short implants in posterior locations.

It can be concluded that multiple splinted short implants are an effective treatment modality in the resorbed mandible and may be used in lieu of bone grafting or nerve transposition.

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