

A 24-YEAR RETROSPECTIVE STUDY OF BONE GROWTH AFTER IMPLANT PLACEMENT

Ralph A. Roberts, DDS

KEY WORDS

Edentulous mandibles
Ramus frame
Bone growth
Increase in biting force
Immediately loaded

This study quantifies the changes in bone height noted in the body of the edentulous mandibles when the load of the complete denture is born by an RA Ramus Frame Implant (Pacific Implant, Rio Dell, Calif). Eighty-three patients with implants were followed for 3 to 24 years. Pre- and postoperative panoramic films were taken and again at each succeeding 5-year follow-up. The results of the bone changes were gathered retrospectively and calculated. The data revealed a significant increase in bone height from 4.413 to 13 mm and statistically significant *P* values of $<.0003$ were determined. The growth of bone appears to be influenced by the design of the posterior feet, dominant chewing side, and a range of extreme atrophy from 5.9 mm to 15 mm. Also, the previously lost anatomical structures appear to repair, such as the luman of the mental foramen and the superior wall over the inferior alveolar canal. All mandibles were loaded postoperatively with an appliance having cutting bars and porcelain teeth or just porcelain teeth in both appliances.

INTRODUCTION

In the annals of implant dentistry and maxillofacial surgery, bone growth after implant placement is looked on with suspicion. For years authors such as Tallgren¹ and Atwood² have written about the irreversible and predictable bone loss of the edentulous mandible. For the past several years, articles have been written with positive discussions about bone regrowth from around previously placed implants.³⁻⁶ Even though the articles' values are small and one might question some of the conclusions, their evidence is positive. Implants are

influencing the maintenance and possible regrowth of bone.

Numerous authors have described the ongoing process of mandibular deterioration.^{1,2,7} Dalangiri and colleagues⁸ noted mandibular resorption and its relationship to loosened dentures. This eventually leads to unstable dentures and, finally, the inability to function, as the alveolus deteriorates to the basal bone and gives rise to a negative ridge.⁸ Reddy⁹ also reported that the use of cylinders in the symphysis region may slow the resorptive process to 0.2 mm of bone loss per year.

Davis¹⁰ and others have reported on the use of cylinders in

Ralph A. Roberts, DDS, is in private practice. Address correspondence to Dr. Roberts at the Pacific Implant Company, 920 Rio Dell Avenue, Rio Dell, CA 95562 (e-mail: robertspac@sbcglobal.net).

the symphysis region with fixed restorations showing 0.18 mm to 1 mm of bone growth around the lateral and mesial surfaces of some of the implant abutments. In extremely atrophied mandibles, Reddy⁹ noted that the crestal ridge distal to the distal implant post elicited 0.18 mm of bone growth on the crest of the ridge. Bettis¹¹ and Baskar⁵ noted an increase in bone height distal to the post when a transmandibular implant was placed with a fixed prosthesis.

The ramus frame is a tripodal design and is supported by the ramii and the syntheses region of the mandible. Its superstructure is a continuous rail above the gum tissue, which supports the prosthesis. Two metal types have been used: (1) stainless steel, used until 1982; and (2) pure titanium, which is currently used. Various posterior foot designs have been used. The current model in use is the RA3 frame, which fits 98% of all cases. The other 2% are served by what is known as the RA3 short rail.

The purpose of this study was to determine what effect the ramus frame had on the edentulous mandible in varying stages of atrophy and the effects of various foot designs in relation to bone.

MATERIALS AND METHODS

Standard medical history and intraoral exams were completed, and all patients were deemed reasonably healthy. Smokers were not excluded from the study; however, smoking has been reported to influence the longevity of implants.¹²⁻¹⁴

When placing Branemark implants, Bain and Moy¹² noted a greater percentage of failures in smokers (11.2%) compared with nonsmokers (4.76%). They cited a study showing that nico-

tine inhibited wound healing in a rabbit ear model. They also cited another study using a rabbit model injected with nicotine. The vascularity of the gingival tissues was constricted, and there increased platelet aggregation as well as increased levels of fibronin. Hemoglobin and blood viscosity were affected and the leukocyte function was compromised.

Charts were gathered on the basis of consistent postoperation follow-up with consistent panoramic X rays taken at each 5-year interval. All variations of the ramus frame were included. The service age of the frames was 3 to 24 years.

Roberts¹⁵ reported a 71% increase in biting force for patients with ramus frame restorations compared with patients functioning with a complete upper and lower denture. A flexure test performed by the University of Alabama-Birmingham revealed that the ramus frame made of commercially pure titanium grade 2 sustained a flexure rate equal to that of the edentulous mandible.¹⁵ Both the ramus frame and subperiosteal implants were found to resist class III masticatory forces and protect the condyle from excessive force, whereas cylindrical implants resisted only class II forces and few, if any, class III forces.¹⁶ The ramus frame has also been reported to protect the anterior maxilla from traumatic occlusion.¹⁷

The ramus frame is a tripodal design. All the osseous sites were prepared with a high-speed dental hand piece, a 557XL carbide bur, and water. After placement, each site was grafted with OsteoGen, (Impladent, Holliswood, NY) to fill any voids around the osseous sites. The 2 posterior feet are placed into the ascending rami, and then the symphysis

receives the anterior foot. The device is immediately loaded by attaching a modified denture to the rail. The frame is designed for all types of mandibular atrophy; however, it serves best in moderate to extreme atrophy cases. A soft diet is recommended for the first 8 weeks.

Panoramic radiographs were taken pre- and postoperatively within a month. Each case was then followed by taking a 5-year panograph. All X rays were taken by a GE Panelipis X-ray machine (Milwaukee, WI) with the exception of 5 films. The same X-ray technician took 80% of all the X rays in this study. A cephalostat device was used to maintain the head within the same plane of occlusion. For means of referencing, all rails and foot portions of the ramus frame implants were 5 mm in height. Several methods are used to calculate for distortional error when using panoramic X rays. Both Reddy⁹ and Davis¹⁰ have used slightly different methods in the analysis of cylinder implants.

In this study it was assumed that if the subject and the machine remained the same, then the distortion factor would also remain the same; therefore, the bone changes of the mandible over time would remain the same. Given this premise, it was theorized that distortion would not influence the linear calculations of bone changes from one X ray to the next. According to Davis,¹⁰ the premolar area has the least magnification in panoramic radiographs and the greatest amount of resorption. Measurements were made from the premolar region because this area has the greatest amount of bone loss,¹⁰ and, according to Batenburg³ and Powers,⁴ has the least variation of magnification in a panoramic radiograph.

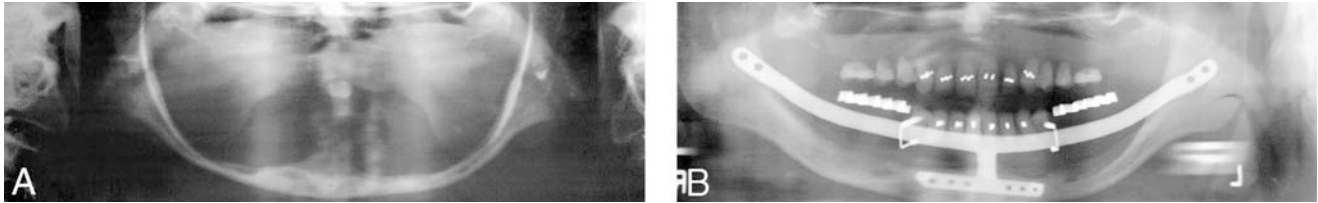


FIGURE 1(A, B). Case 1. Preoperative panoramic X ray taken in 1991; postoperative in 2000. (A) Left side showing 4.33 mm of vertical bone growth and right side showing 7.26 mm. (B) In this patient the right side was the dominant chewing side.

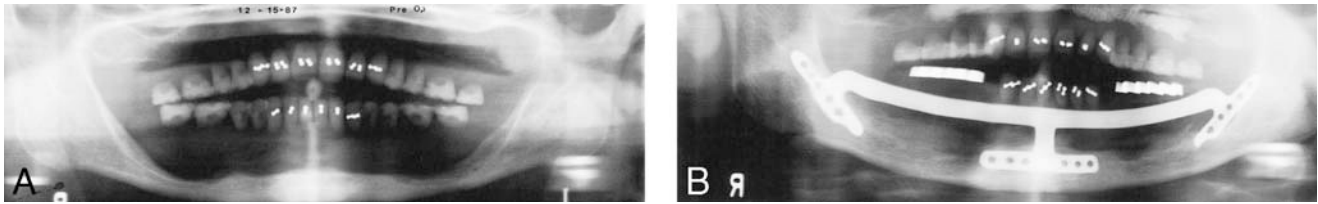


FIGURE 2(A, B) Case 2. (A) Preoperative panoramic X ray taken in 1987; postoperative in 2002. (B) Left side showing 3.89 mm of vertical bone growth and right side showing 9.62 mm. In this patient the right side was the dominant chewing side.

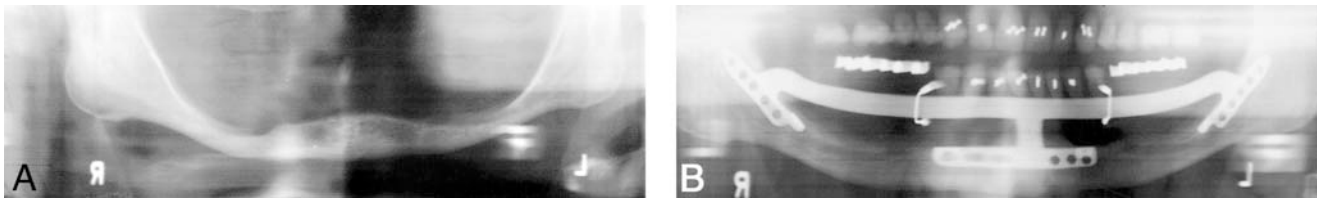


FIGURE 3(A, B). Case 3. (A) Preoperative panoramic X ray taken in 1992; postoperative in 1999. (B) Left side showing 4.28 mm of vertical bone growth and right side showing 5.76 mm. In this patient the right side was the dominant chewing side.

Two investigators independently made measurements. A view box with controlled lighting was used to delineate the margins of the bone more clearly. The criterion was to locate and measure the least bone height of each mandibular hemisphere from the inferior border to the residual

crust. For the most part, this location was found to be just distal to the mental foramina. However, this landmark was not present in many of the cases because of atrophy.

After determining the lowest point, a vertical line was drawn from the base of the mandible to

the residual crest, and this position was replicated on the succeeding film of each patient. A Fowler caliper micrometer was used to take the measurement. After all the data were gathered, *P* values were assessed by using the analysis of variance test and adjusted for any possible compounding by age, gender, and years in service. The significance of these differences was still evident in these elderly patients (Figures 1 through 4).

RESULTS

After processing, the data were divided into 4 distinct groups (Table 1, Figures 5 and 6).

The patients' dominant chewing sides were determined. By applying this factor to the data,

TABLE 1
Types of implants used

Implant	No. of Patients	Average Bone Growth (mm)		Average Age of Patients (y)	Years in Service	Range of Bone Height (mm)
		Left	Right			
Stainless steel	7	1.34	1.50	73.9	23.50	
RA2 titanium	19	2.96	3.64	70.63	12.50	
RA2, RA3 titanium	22	1.84	1.973	70.96	10.95	15-33.75
RA3 titanium	35	4.189	4.413	70.62	10.89	5.96-15.32

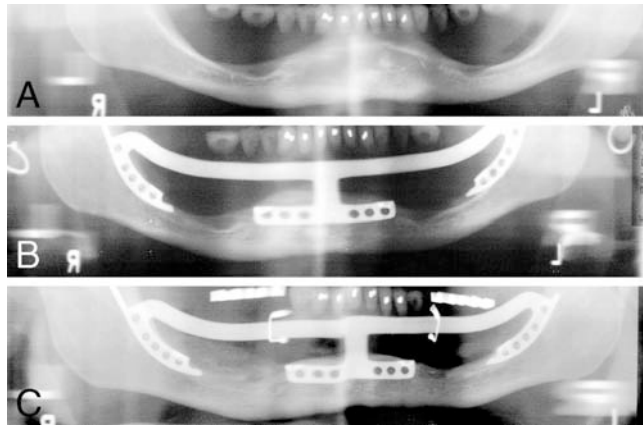


FIGURE 4(A, B). Case 4. (A) Preoperative panoramic X ray taken in 1988; postoperative in (B) 1989 and (C) 2000. Left side showing 3.42 mm of vertical bone growth and right side showing 13.01 mm. In this patient the right side was the dominant chewing side.

a direct correlation was detected between bone growth and the patients' dominant chewing sides. The patients in the group having bone heights of 5.98 mm to 15 mm also showed the largest vertical bone growth, whereas those in the group having bone heights of 15 mm to 33.75 mm showed only marginal bone growth (note Table 1). This clearly illustrates that 15 mm of growth is maximum for the applied stimulus to the bone. Four patients in the larger bone mass group also showed the largest number of negative values for 1 side, and the patient with the highest bone mass of 32.48 mm to 33.75 mm had the largest negative values of -1.65 and -1.17.

The RA3 group is the only group who had statistically significant *P* values < .05 (see Table 2). This group has demonstrated radiographic reappearance of previously lost anatomical structures such as the mental foramen and the reformation of the mandibular canal over the neurovascular bundle (see Figures 1 through 4).

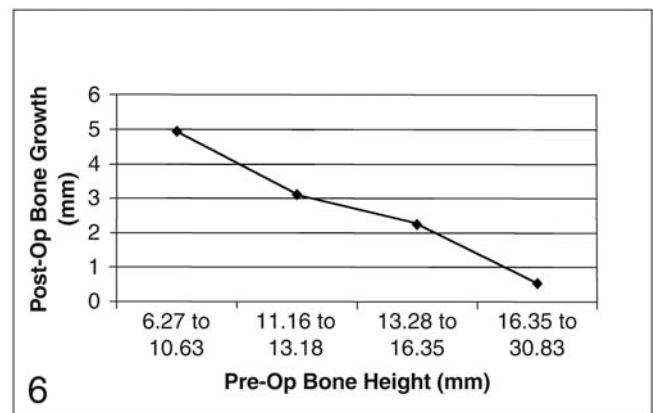
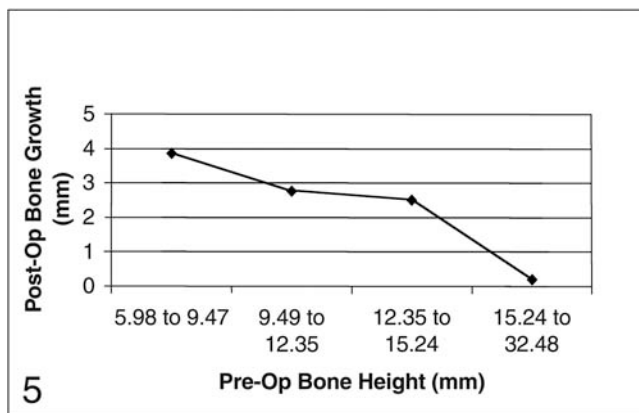
DISCUSSION

This study found that ramus frames implanted into the mandible appeared to stimulate measurable bone growth from 4.413 mm to 13 mm.

The forces of mastication are transferred over a broad area within the symphysis and rami of the mandible. This broad distribution of force makes immediate loading possible. Such stresses and strains to the mandible may stimulate bone growth.^{15,17}

All 4 treatment categories received a mandibular denture with cutting bars (a mono occlusion) and an opposing maxillary denture with porcelain teeth or natural teeth with porcelain below. They were all loaded immediately, and all the osseous sites were prepared in the same way with a high-speed bur and copious irrigation. Postoperative antibiotics were prescribed for 1 week. No postoperative complications were reported, and all sites healed uneventfully.

Wolff's Law describes the applied forces best: when a stress is applied to a bone, a charge differentiation is created.^{9,10,18,19} Areas of tension develop a negative charge, and areas of compression develop a positive charge. The charge developed has an inductive influence on cells. Areas of negative charge stimulate osteoblastic activity. This may describe the osteoblastic activity of the mandible. After restoration, the muscles of mastication are also able to work more



FIGURES 5-6. FIGURE 5. RA3 frames, left side. FIGURE 6. RA3 frames, right side.

efficiently in applying the needed forces to the masticating process without pain to the patient. Much greater forces can now be applied via the muscles of mastication to more properly masticate the foods. Nearly all the edentulous patients have a distressed digestive system. After receiving a ramus frame, the patients claim a dramatic improvement with their digestive process. Posterior foot design is one of the single largest factors in the success or failure of the ramus frame. The M1 and RA1 have both shown a lack of adequate support. The RA2 is largely supportive; however, when forces over 35 pounds are applied to the rail, the device tends to torque medially. Although patients in this study were functioning quite well, the device did not produce the *P* values comparable with the RA3. The RA3 has the most balanced foot and is supported by its *P* values (Table 2).

After using tabbing for 10 years, it was found to be unnecessary with the use of titanium, which has the ability to achieve intimate apposition with bone. No appreciable settling of the titanium frames has occurred. The overall health of a patient is decreased by the degree of ridge resorption and a poor masticatory function.²

CONCLUSION

The ramus frame is a very comfortable and stable implant that may distribute occlusal stresses in a magnitude that stimulates bone growth of the mandible.

To see generalized bone growth of 4.413 mm to 13 mm, especially in atrophic mandibles that are less than 6 mm in height, is an exciting new finding. It is also a revolutionizing treatment for atrophic mandibles, especially

Quadrant	Range (mm)	Difference (mm)	n	<i>P</i> Value
Left	5.98–9.47	3.8525	13	.0003
Left	9.49–12.35	2.7792	13	.0001
Left	12.35–15.24	2.5192	13	.0003
Left	15.24–32.48	0.1942	12	.7023*
Right	6.27–10.63	4.9567	12	.0000
Right	11.16–13.18	3.0631	13	.0004
Right	13.28–16.35	2.27	12	.0011
Right	16.35–30.83	0.4992	12	.3847*

*Not significant.

if the patient does not have to undergo extensive bone grafting procedures.

After viewing several X rays from previously placed ramus frames dating back to 1979, an unexpected finding of what appeared to be an increase in mandibular body height was observed. A careful observation of other patients' records led to this extensive study. A generalized bone growth in atrophic mandibles was observed in 83 patients who had received ramus frames over the past 24 years. The bone growth in all these patients appears to be not only a serendipitous happening but also very much a scientific fact. This introspective analysis appears to challenge our present-day thinking and lays down new principles and contexts for treating the atrophic mandibles in the future (Figure 1).

NOTE

The author is owner and president of the Pacific Implant Company and acknowledges financial interest in the RA Ramus Frame Implant.

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complete denture wearers. A mixed longitudinal study covering 25 years. *J Prosthet Dent.* 1972;27:120–132.

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