Effect of Artificial Tooth Material on Mandibular Residual Ridge Resorption

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Abstract

Purpose: *In this 10-year longitudinal study we evaluated the amount of mandibular residual ridge resorption for 2 groups of subjects with complete dentures, one group with porcelain artificial teeth and the other with acrylic resin teeth.*

Methods: *One hundred and nine patients who had undergone ridge extension procedures with skin graft and prosthetic rehabilitation with porcelain or acrylic resin teeth were investigated for mandibular bone loss. Measurements were made on serial cephalograms.*

Results: *There were no significant differences between the groups in terms of their baseline characteristics (age, period of edentulousness, period of observation, vertical facial morphology, sex, severity of atrophy or presence of bruxism). Similarly, there were no statistically significant differences in amount of bone loss in relation to baseline characteristics.*

Conclusion: *The view that acrylic resin teeth should be preferred to prevent bone resorption of the mandibular residual ridge is not supported by these data. Further research concerning soft denture-lining material should be undertaken to elucidate the potential role of denture pressure in ridge resorption.*

MeSH Key Words: *alveolar bone loss; denture, complete, lower; tooth, artificial*

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Lateral cephalometric measurements obtained in long-term studies after dental extraction have shed some light on residual ridge resorption.[1-3] This process is slow, gradual and inevitable. Loss of bone beneath dentures follows a decreasing exponential curve. The loss is rapid in the first years after placement of dentures, then continues at a slower pace, continuing even after 25 years. Great variations in the degree of bone loss are seen, especially in the anterior region of the mandible,[4] which is 4 times more affected than the maxillary ridge, which benefits from the presence and support of the palate and from a larger denture-bearing area.

A variety of factors are involved in residual ridge resorption, some local, others systemic.[5,6] For example, compressive forces are known to be harmful to bone. Zarb,[7] in the most recent edition of Boucher's textbook on prosthodontics, stated, "Many dentists have been tempted to equate the prevalent residual ridge reduction in the edentulous population with increased stresses imposed on these ridges." Pressure exerted by dentures on mucous membranes would interfere with blood flow, upsetting the metabolism of the tissues involved. Although not proven, it is tempting, as Zarb mentions, to include parafunctional habits such as bruxism as possibly significant variables affecting the magnitude of ridge reduction. Therefore, efforts should be directed to developing permanent lining material that will lessen the pressure on the supporting tissues.

In this context of forces transmitted to the residual ridge the question arises of whether a material with a higher coefficient of elasticity, such as that used in acrylic resin artificial teeth, would be less harmful to the residual ridges.

This 10-year longitudinal study was undertaken to compare the amount of mandibular ridge resorption between 2 groups of subjects with complete dentures, one group with porcelain artificial teeth and the other with acrylic resin artificial teeth.

Methods

The study population consisted of 109 patients with complete dentures: 69 with porcelain anatomic teeth and 40 with acrylic anatomic teeth. The 83 women and 26 men (mean age 49 years, standard deviation 10 years) were part of a large database of patients who had undergone reconstructive surgery for atrophy of the residual mandibular ridge. All patients in the database who had not received ridge augmentation with alloplastic material or bone grafts and who had a minimum of 3 sequential cephalograms were included in the study.

The surgical procedure used to improve ridge form was a total lowering of the floor of the mouth with vestibuloplasty. A split-thickness skin graft was applied to cover the extended ridge that had been freed from the interference of muscle attachments. Prosthetic rehabilitation with complete dentures was carried out at the Maxillary Atrophy Clinic of St. Mary's Hospital, Montreal, by a prosthodontic team made up of 1 prosthodontist and 2 dentists. Maximal use of lingual undercuts obtained by surgery provides stability and retention of the denture.[8] Bioblend (Dentsply Canada Limited, Woodbridge, Ont.) anatomic porcelain teeth were preferred at this clinic. This choice was dictated mainly by socioeconomic considerations (since these teeth have greater durability than other types). Conventional anatomic teeth made of acrylic resin were used when space was lacking in the posterior regions or at the patient's request.

The observation periods for clinical and radiographic examinations were set at 1, 3, 5, 7 and 10 years.

Lateral cephalometric measurements were taken with the same cephalostat before surgery and at each clinical visit. The technique of measurement has been described previously.[6,9] It is based on reproducible points and is similar to methods used in other studies.[1-3] Linear measurements were taken at 3 different sites on the body of the mandible (at Ht10, Ht20 and Ht30). These heights were measured from the lower border to the summit of the crest, at 10, 20 and 30 mm from point 0 on the Go-Me (gonion-menton) plane, a tangent of pogonion (pog) at right angles to the Go-Me plane (Fig. 1).

Whenever the 2 lower borders were not superimposed on the radiograph, the lower border of the superimposed upper border was used as the starting point for measurement to the superior crestal point. The angle of the mandibular plane that defines the vertical facial morphology is measured from points Ar (articular), Go and Me.

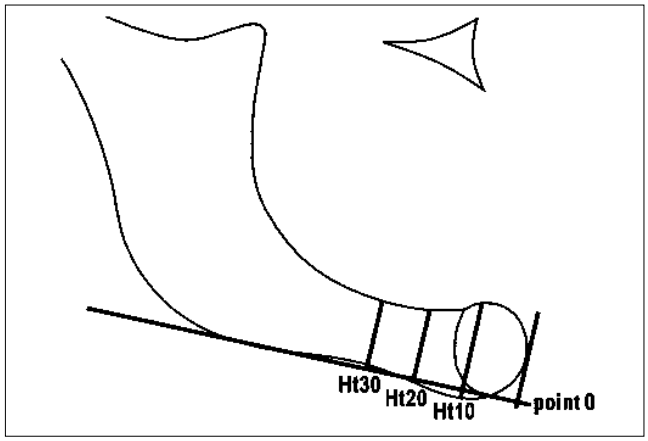

Figure 1: *Technique of measurements of mandibular bone height on cephalograms*

Baseline characteristics (age, period of edentulousness, period of observation, facial morphology with regard to degree of bite opening, sex, severity of atrophy and presence of bruxism) were compared between the 2 groups with *t*-tests or chi-square tests as appropriate. The height measurements for each group were compared at each observation point by means of a *t*-test. The relationships between bone loss after 10 years of observation and baseline characteristics were evaluated with one-way analysis of variance (ANOVA) or Pearson correlation coefficients as appropriate. The level of significance was set at 5%. All analyses were conducted with SAS software for Windows (Version 6.12, SAS Institute Inc., Cary, N.C.).

Results

The mean observation period was 8.8 years (standard deviation 1.9 years); 75 (69%) of the patients reached the 10-year observation point.

Table 1 Baseline characteristics of patients with complete dentures made of porcelain or acrylic resin artificial teeth

Variable	Porcelain (*n* = 69)	Acrylic resin (*n* = 40)	*p* value
Mean age ± SD (years)	49.0 ± 10.9	48.1 ± 9.3	0.654[a]
Mean period of edentulousness ± SD (years)	19.0 ± 10.3	18.7 ± 10.1	0.899[a]
Mean period of observation ± SD (years)	8.8 ± 1.8	8.9 ± 2.1	0.884[a]
Mean ArGoMe angle ± SD (degrees)	129.6 ± 5.7	127.3 ± 7.1	0.068[a]
Sex (no. and % female)	53 (77)	30 (75)	0.831[b]
Severity of atrophy (no. and %)			0.756[b]
Light	8 (12)	6 (15)	
Moderate	38 (55)	18 (45)	
Severe	16 (23)	12 (30)	
Very severe	7 (10)	4 (10)	
Presence of bruxism (no. and %)	19 (28)	16 (40)	0.179[b]

SD = standard deviation
[a]*t-test*
[b]*Chi-square test*

Table 2 **Comparison of ridge resorption at different levels of the mandible for patients with complete dentures made of porcelain or acrylic resin artificial teeth**

Variable and observation period	Porcelain		Acrylic resin		
	n	Mean height ± SD (mm)	*n*	Mean height ± SD (mm)	*p* value[a]
Ht10					
Pretreatment	68	18.9 ± 3.3	40	18.4 ± 4.7	0.473
1 year	68	18.3 ± 3.1	39	18.2 ± 3.5	0.928
3 years	59	17.6 ± 2.8	36	17.2 ± 3.4	0.517
5 years	58	17.7 ± 3.0	34	17.3 ± 3.2	0.601
7 years	50	17.2 ± 2.8	25	17.0 ± 2.5	0.808
10 years	47	16.5 ± 3.4	29	16.8 ± 3.8	0.724
Bone loss after 10 years[b]	47	2.5 ± 1.8	29	2.4 ± 2.3	0.818
Ht20					
Pretreatment	69	17.8 ± 4.3	40	17.8 ± 4.9	0.955
1 year	67	17.2 ± 4.0	39	17.2 ± 4.8	0.977
3 years	59	16.9 ± 3.6	37	16.4 ± 4.7	0.545
5 years	59	16.7 ± 3.8	34	16.4 ± 4.5	0.727
7 years	52	16.3 ± 3.8	25	16.3 ± 4.2	0.994
10 years	49	15.8 ± 4.0	28	16.0 ± 4.9	0.831
Bone loss after 10 years[b]	49	1.8 ± 1.9	28	2.4 ± 2.4	0.239
Ht30					
Pretreatment	69	14.9 ± 3.9	40	15.0 ± 4.5	0.877
1 year	64	14.5 ± 3.6	39	14.7 ± 4.5	0.837
3 years	59	14.0 ± 3.2	37	14.2 ± 4.5	0.787
5 years	59	13.9 ± 3.2	33	14.0 ± 4.5	0.855
7 years	51	13.6 ± 3.3	25	13.9 ± 3.9	0.718
10 years	48	13.0 ± 3.3	29	13.7 ± 4.3	0.485
Bone loss after 10 years[b]	48	1.7 ± 1.9	29	1.7 ± 1.8	0.895
Mean of Ht10, Ht20 and Ht30					
Pretreatment	68	17.2 ± 3.5	40	17.1 ± 4.0	0.827
1 year	64	16.7 ± 3.4	39	16.7 ± 4.1	0.996
3 years	58	16.2 ± 3.0	36	16.0 ± 4.1	0.779
5 years	58	16.1 ± 3.1	33	15.9 ± 4.0	0.774
7 years	49	15.7 ± 3.1	25	15.7 ± 3.4	0.940
10 years	47	15.1 ± 3.4	28	15.6 ± 4.2	0.612
Bone loss after 10 years[b]	47	2.0 ± 1.5	28	2.2 ± 2.0	0.647

[a]*t-test*
[b]*Pretreatment measurement — measurement at 10 years*

There was no significant difference between the 2 study groups in terms of baseline characteristics, specifically mean age, mean period of edentulousness, mean period of observation and facial morphology in terms of mean mandibular plane angle (Table 1). Similarly, the percentage of women was similar in the 2 groups, as were the distribution of severity of atrophy and the percentage of patients with bruxism.

The mean pretreatment measurement of Ht10 was 18.9 mm for the porcelain denture group and 18.4 mm for the acrylic denture group ($p = 0.473$). The mean bone loss at Ht10 after 10 years was 2.5 mm for the porcelain denture group and 2.4 mm for the acrylic resin denture group ($p = 0.818$). Similar results were observed for Ht20, Ht30, and the mean of Ht10, Ht20 and Ht30 (Table 2). In summary, there were no statistically significant differences in height measurements between the 2 groups over the entire study period.

There was no statistically significant relationship between bone loss and sex, severity of atrophy, bruxism, age or mandibular plane angle (Table 3). However, a statistically significant negative relationship was found between bone loss and period of edentulousness ($r = –0.294$, $p = 0.010$).

Discussion

Grant has summarized the advantages and disadvantages of porcelain and acrylic resin artificial teeth (Table 4).[10] The simplicity of adjustments to acrylic teeth, which can be ground without any severe effect on their adhesion to the denture base, as well as the ease of denture fabrication and polishing after adjustments, stand out as the main factors for the choice of these teeth by most clinicians.

The great popularity of acrylic resin teeth was also acknowledged in a survey of North American dental schools.[11] Nevertheless, porcelain remains an outstanding material, recognized in particular for its durability, which is superior to that of acrylic, despite progress in the development of highly cross-linked acrylic resins that are less susceptible to wear than conventional ones. For example, in our hospital-based clinic, we have frequently observed porcelain dentures with almost-intact cusps after 10 years of use.

Jacob[12] has recently stated that today's clinical techniques and judgements in complete-denture therapy represent an amalgamation of original prosthodontic philosophies, including approaches to the fabrication of dentures and their scientific bases. She deplored the paucity of procedural research in clinical investigations.

Variations in denture technique that may affect bone loss have been investigated.[13] No differences of statistical significance were found in the amount of bone lost, whether a simple or a conventional denture technique was used. Unfortunately, the authors of the study did not specify whether the teeth were made of acrylic or porcelain.

A review of complete-denture textbooks revealed that the question of ridge resorption in relation to the material

Table 3 **Relationship between bone loss after 10 years and baseline characteristics among patients with complete dentures**

Variable	*n*	Mean bone loss[a] ± SD (mm)	*p* value
Sex			0.142[b]
Female	56	1.9 ± 1.7	
Male	19	2.6 ± 1.6	
Severity of atrophy			0.242[b]
Light	12	2.8 ± 1.3	
Moderate	40	2.1 ± 1.7	
Severe	20	1.9 ± 1.8	
Very severe	3	0.9 ± 1.0	
Bruxism			0.358[b]
No	47	2.2 ± 1.4	
Yes	28	1.8 ± 2.0	
Age	75	–0.087[c]	0.458
Period of edentulousness	75	–0.294[c]	0.010
ArGoMe angle	75	–0.075[c]	0.525

SD = standard deviation
[a]Difference between pretreatment value and value at 10 years (mean of Ht10, Ht20 and Ht30)
[b]One-way analysis of variance (ANOVA)
[c]Pearson correlation coefficient

Table 4 **Characteristics of porcelain and acrylic resin artificial teeth (adapted from Grant[10])**

Characteristic	Porcelain	Acrylic resin
Rate of wear	Very slow	May be rapid
Brittleness	May chip	Will not chip
Ease of adjustment	More difficult to grind and polish	Easy to grind and polish
Density (g/m^2)	2.34	1.18
Esthetics	Can be excellent	Can be excellent
Ease of modification	Difficult to characterize	Simple to characterize
Retention to base	Mechanical bond	Chemical bond
Transmission of occlusal force	Considered to transmit all forces	Considered to transmit reduced forces
Noise during use	Sharp impact sound	Little sound on contact

used in artificial teeth (porcelain or acrylic resin) remains unsolved to date.[10,14-16]

The present study represents an attempt to correlate the baseline characteristics of subjects, including facial morphology, with bone loss and with differences in artificial tooth material. Several authors have found that the magnitude of bite force is related to craniofacial morphology.[17-19] The smaller the mandibular plane angle or the closer the bite, the stronger the forces exerted on the body of the mandible. Craniofacial morphology is also related to the amount of residual ridge loss.[20,21] It has been pointed out that non-masticatory pressure over the denture base during swallowing, smoking and especially teeth clenching is as great as pressure during mastication.[7,22] Stress-induced muscle activity that prolongs tooth contact during swallowing, speaking or smoking has been observed among patients who report denture soreness.[23] Patients with bruxism who wear dentures while sleeping exhibited more severe atrophy.[6]

It could be assumed from these studies that the forces exerted by mastication and parafunctional habits on the residual ridge would be dampened by acrylic resin teeth, which have a certain degree of resiliency. Masticatory forces, represented in this study by mandibular plane angle, bruxism and the period during which the ridges were submitted to denture pressure, should have been determinant factors. However, our results failed to show any influence of artificial tooth material on mandibular ridge resorption.

Although pressure causing resorption might still be an important if as-yet-unproven factor, the inconclusive results of this study support the opinion of Sharry,[24] who has stated that the forces necessary to deform the teeth and thus to bring into play the dampening factor of acrylic resin are greater than those used by patients. Moreover, it was remarked in Neil and Nairn's[16] textbook on complete-denture prosthetics that the result of masticatory forces on different artificial tooth materials is distributed to the denture base, which is made of the same material in all cases. The effect of using different materials for the teeth would thus be marginal.

Conclusions

This study may serve to enhance future research on the denture-pressure phenomenon and the development of better soft denture-lining material. Since it appears that the intermediate milieu by which forces are transmitted to the denture base, the artificial teeth, does not play an important role in ridge resorption, further steps can be taken to elucidate the situation. A longitudinal study starting immediately after extraction, when ridge resorption is intense, could be undertaken to compare the rate of bone loss in a group of patients with soft denture linings and another group with conventional hard denture bases. Such a study would be a valuable contribution to knowledge about a phenomenon that will affect an increasing number of people.

A World Health Organization data bank on oral health has revealed an alarming increase in the prevalence of dental caries in the poor nations of Latin America and the former socialist economy countries.[25] There is a good chance that a pattern of health-related problems similar to that experienced in the past within more affluent nations will develop.

An increasing number of denture wearers will be exposed to ridge loss, unstable dentures and associated physical handicap, which will affect their well-being and general health. It is the obligation of countries with established market economies, whose populations no longer experience severe dental caries and total edentulism, to lead the way in promoting research efforts in this direction. ➧

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