Implant-Supported Versus Implant-Retained Distal Extension Mandibular Partial Overdentures and Residual Ridge Resorption: A 5-Year Retrospective Radiographic Study in Men

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Purpose: This retrospective study sought to examine posterior mandibular ridge resorption under implant-supported and implant-retained distal extension partial overdentures in men at the end of a 5-year observation period. ***Materials and Methods:*** Class I mandibular partial edentulism was managed in 34 patients with removable partial overdentures that were adjunctively supported (n = 18) or retained (n = 16) via resilient attachments placed bilaterally on single implants (n = 68) in the first molar areas. Posterior Area Indices (PAI) were calculated for each patient by digitizing the traced rotational tomograms taken immediately before and after 5 years of treatment. Proportional rather than actual measurements were used in an effort to minimize errors related to magnification and distortion. ***Results:*** Residual ridge resorption associated with the implant-supported partial overdentures was recorded as PAI =0.012 ± 0.022; it was PAI = 0.073 ± 0.044 for the implant-retained group. Estimated average reductions in ridge heights were 0.15 and 1.03 mm for implant-supported and implant-retained partial overdentures, respectively. Multiple linear regression models demonstrated that prosthesis type, initial mandibular ridge height, and relining frequency were significantly correlated with PAI. ***Conclusion:*** Implant-supported partial overdentures appear to be associated with reduced posterior mandibular alveolar ridge resorption when compared to implant-retained ones. *Int J Prosthodont 2011;24:306–313.*

The duality of support that characterizes distal extension removable partial dentures (RPDs) is often characterized by time-dependent adverse changes in both the abutment teeth and edentulous areas.[1] Consequently, adjunctive implant support has been proposed for mandibular Class I and II removable partial denture designs.[2,3] The premise is that this will minimize the risk of potential problems of patient discomfort associated with prosthesis retention and stability resulting from residual ridge resorption.[4,5]

The aim of this preliminary study was to retrospectively compare the possible influence that implant placement under distal extension RPDs might have on the residual ridges in treated Class I mandibles at the end of a 5-year observation period.

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Materials and Methods

Thirty-four healthy men who regularly attended the Department of Removable Prosthodontics, Faculty of Dentistry, Mansoura University, Egypt, for dental follow-up treatment were recruited for this study. They were enrolled following their acceptance of the faculty committee's duly approved and explained research protocol, and a signed informed consent form was obtained. Each patient had been partially edentulous in the mandible for 3 to 8 years and either already wore or was a candidate for wearing an RPD because of the presence of only eight anterior teeth (first premolar to first premolar) opposing a complete maxillary denture. The study's sample size of 34 men (age range: 44 to 61 years) was calculated to yield a power of 80% (two-tailed α = .05) using a computer program (Power and Precision version 3, Biostat). Calculations were based on results from previous studies[6–8] that demonstrated that a .06 change in Posterior Area Index (PAI) between treatment groups is regarded as significant. Single bilateral implants (Dyna Dental Engineering) were placed in the edentulous first molar area of the distal extension ridges using a standardized two-stage submerged surgical protocol. Table 1 shows the distribution of implant lengths and diameters for all patients.

Table 1 Dimensions of Implants Used

	Length								
	8.0 mm		10.0 mm		11.5 mm		13.0 mm		Total no. of implants
Diameter	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	
3.6 mm	0	0	0	1	1	1	2	3	8
4.2 mm	1	1	4	2	3	2	2	2	17
5.0 mm	1	0	2	0	1	2	1	2	9
Total	2	1	6	3	5	5	5	7	34

Group 1 = implant-supported partial overdenture; group 2 = implant-retained partial overdenture.

Fig 1 Implant-supported partial overdenture.

Fig 1a Healing abutment on the cast.

Fig 1b Metal framework contact on the fitting surface of the partial overdenture.

Fig 1c Healing abutment in place.

The partial overdenture design prescribed for all patients relied on lingual bar major connectors, bicuspid abutments with RPA (mesial occlusal rest, distal proximal plate, Aker arm) clasp assemblies for retention support, and indirect retention from canine cingulum rests.

After construction of the mandibular cobalt-chromium alloy frameworks, an impression was recorded for the distal extension ridges using a mixture of equal parts medium- and light-bodied polyether material (Impregum F and Permadyne LV, 3M ESPE), and an altered cast impression technique was employed.[9] Semianatomical acrylic resin teeth (Vitapan, Vita Zahnfabrik) were arranged to ensure balanced occlusal contact.

Patients were then divided randomly into two groups according to the overdenture design concepts employed using a computer program. Group 1 included 18 patients treated with implant-supported partial overdentures with direct contact of the metal framework to the top of each healing abutment (Fig 1). Disclosing wax (Kerr) was used intraorally to eliminate extraneous contact other than that on the top of each healing abutment to reduce lateral forces on the implants[3] and permit axial loading. Group 2 included 16 patients treated with implant-retained partial overdentures via a resilient attachment (Ball Abutment and Gold Smart Matrix, Dyna Dental Engineering). Positioning rings were placed over the ball abutments to create space between the matrices

Fig 2 Implant-retained partial overdenture.

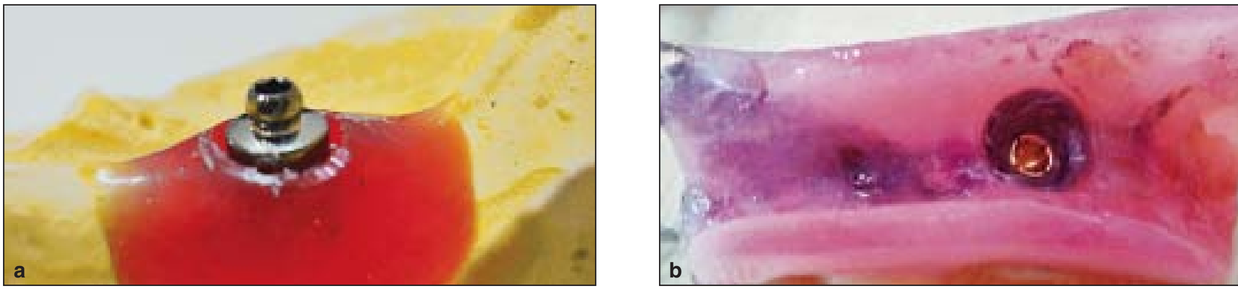

Fig 2a Ball abutment on the cast.

Fig 2b Gold smart matrix on the fitting surface of the partial overdenture.

Fig 2c Ball abutment in place.

and balls. The matrices were functionally related to the denture-fitting surface by direct pickup using autopolymerizing acrylic resin. The positioning rings were removed to allow vertical play of the denture on loading (Fig 2).

Patients were recalled every 6 months to check the top contact in group 1 and the space between the components of the resilient attachment in group 2 using disclosing wax. If contact existed between the matrices and balls in group 2, the matrices were separated from the denture base and a “pickup” procedure was repeated with positioning rings in place. Two prosthodontists who were blinded to the treatment groups determined the need for relining by checking the occlusion and evaluating the tissue fit of the denture base using a thin mixture of irreversible hydrocolloid impression material (Alginate CA 37 Superior Pink, Cavex Holland).[10]

Data Collection from Tomographic Images

Two rotational tomograms for each patient (taken immediately before [baseline] and 5 years after overdenture insertion) were obtained from available patient records during routine examination. To standardize all tomographic images, the panoramic unit (Orthophos Plus, Siemens) was operated at 69 kV with a constant current of 16 mA/s and an exposure time of 16 seconds while each patient bit down on a custom acrylic occlusal stent connected to the chin stabilizer of the unit. The films were processed in an automatic processor. All radiographs were examined carefully to select only those clearly showing all the main points to be traced. The mandibular ridge heights at the region of the mental foramen and the ridge lengths were measured from rotational tomograms taken at baseline. Relining frequency for both groups was also recorded.

Evaluation of Posterior Mandibular Alveolar Bone Changes

Bilateral posterior areas of the residual ridges were measured on rotational tomograms using a method of proportional measurement that was similar to that described by Wilding et al.[11] Boundaries for the posterior area were identified by drawing a line joining the gonion to the lower border of the mental foramen and the crest of the residual ridge. The area was expressed as a proportion of a further area of bone, which was independent of the crest of the residual ridge (a posterior triangle formed on each side

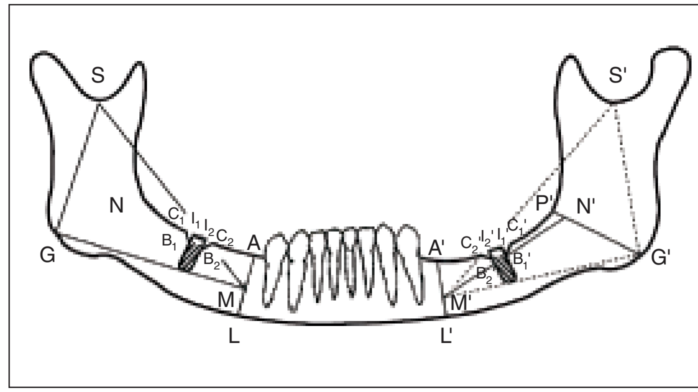

Fig 3 The lower border of the mental foramen (M, M'), the sigmoid notch (S, S'), and the gonion (G, G') were used to construct the triangles M-S-G and M'-S'-G', with centers N and N', respectively. Boundary lines were constructed as follows: M-G and M'-G', A-L and A'-L' (crest of the residual ridge to the lower border of the mandible perpendicular to M-G and M'-G'), M-N and M'-N', and G-P and G'-P' (G-N and G'-N' extended to the crest of the residual ridge at P and P'). The lines C_1-B_1 and C_1'-B_1' (line from marginal bone level [point C_1, C_1'] to first bone-to-implant contact [point B_1, B_1']) and B_1-I_1 and B_1'-I_1' (line from point B_1, B_1' to implant shoulder [point I_1, I_1']) were measured at the distal aspect of the implants. The lines C_2-B_2, C_2'-B_2', B_2-I_2, and B_2'-I_2' were measured at the mesial aspect of the implants.

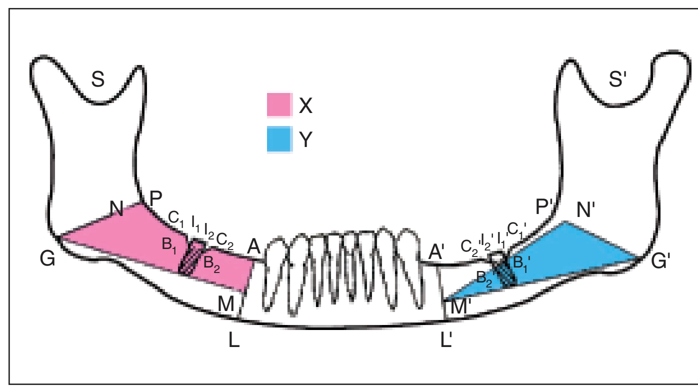

Fig 4 The areas were defined as follows: X and X' were defined by the crest of the residual ridge P-C_1-B_1-I_1-I_2-B_2-C_2-A and P'-C_1'-B_1'-I_1'-I_2'-B_2'-C_2'-A' and the boundary lines A-M and A'-M', M-G and M'-G', and G-P and G'-P', respectively; Y and Y' were defined by the triangles M-G-N and M'-G'-N', respectively. PAI was calculated as (X/Y + X'/Y')/2.

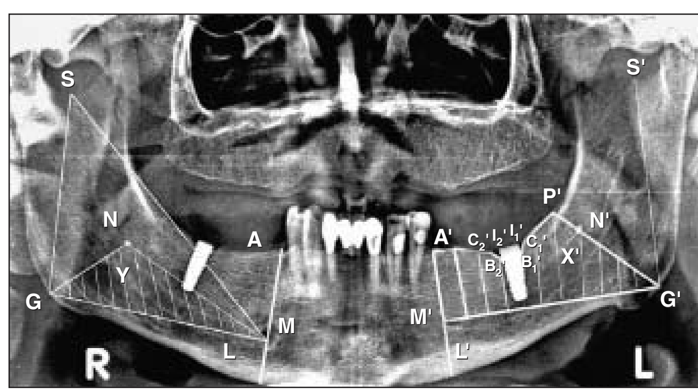

Fig 5 Traced rotational tomography with reference points and lines.

connecting the gonion, the lower border of the mental foramen, and a point that was the center of triangle gonion–mental foramen–sigmoid notch). In this study, a modification was introduced to this method to subtract peri-implant crestal bone loss from the posterior mandibular areas (Figs 3 and 4). Therefore, patients who had excessive peri-implant bone loss were excluded to avoid misleading values of PAI.

The rotational tomogram films were scanned using a black and white translucent scanner. The landmarks were traced on the images and digitized, and the necessary calculations were performed using the assisted drawing program AutoCAD 2008 (Autodesk) (Fig 5).

The mean differences for right and left PAIs were calculated for each patient. The area difference, which represents bone resorption along the entire ridge length, was estimated by multiplying the average initial area with the value of the change in PAI. Then, approximate changes in height could be calculated by dividing the change in bone area by the average length of the posterior residual ridge.[8]

Table 2 Clinical and Radiographic Characteristics of the Study Population

	Age		Ridge length (mm)		Years edentulous		No. of dentures worn		Initial height of mandible (mm)		Relining frequency	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Group 1	55.0	48–61	44.0	39–47	6.2	4–8	1.6	0–3	16.3	14–19	0.06	0–1
Group 2	49.2	44–55	42.5	39–46	5.5	3–8	1.1	0–3	18.5	15–21	0.46	0–2
t test	*P* = .00		*P* = .10		*P* = .14		*P* = .14		*P* = .001		*P* = .033	

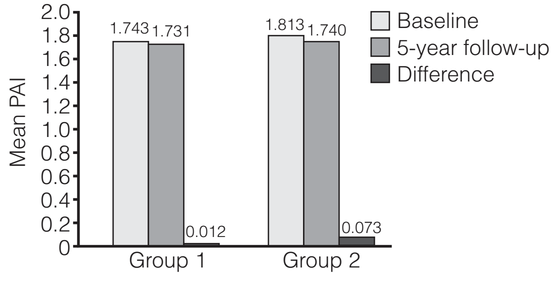

Fig 6 PAI at baseline and the 5-year follow-up for both groups.

Table 3 Mean Difference in PAI Between Groups

	Mean change in PAI ± SD	Maximum PAI	Minimum PAI
Group 1	−0.012 ± 0.022	+0.03	−0.05
Group 2	−0.073 ± 0.044	−0.16	−0.02
Independant *t* test	*P* = .00		

SD = standard deviation.

Data Analysis

All data were analyzed using SPSS version 10 (IBM). Descriptive statistics were taken for all patients at the beginning of the study. Radiographic measurements were completed by a single operator blinded to the treatment groups. The mean differences in PAIs were compared within the same group using paired sample *t* tests and between groups using independent sample *t* tests. A multiple regression analysis using a stepwise procedure was also performed to test if there was a relationship between PAI and potential confounding factors: type of prosthesis, age, ridge length, years of edentulism, number of worn dentures, initial ridge height of the mandible, and relining frequency. A *P* value of ≤ .05 at a confidence interval of 95% was considered significant.

Results

The total number of subjects at baseline was 34. Two patients were omitted from further investigation (1 in each group) because of unidentified mental foramina on their rotational tomograms. Another 2 patients in group 1 were excluded because they had excessive peri-implant crestal bone loss that accompanied late implant failures. Therefore, 30 patients (30 pairs of radiographs) were suitable for the study (15 pairs in each group).

The descriptive statistics of the study population are shown in Table 2. An independent sample *t* test showed that patients in group 1 were significantly older in comparison to patients in group 2 (*P* = .00). There was also a significant difference between groups in both initial height of the mandible and relining frequency (*P* = .001 and *P* = .033, respectively). However, time of edentulism, number of worn dentures, and ridge length demonstrated no significant difference between the two groups at baseline.

PAI results for both groups are shown in Fig 6. There was no significant difference in PAI between baseline and the 5-year follow-up in group 1, while in group 2, PAI at 5 years was significantly less than PAI at baseline (paired samples *t* test, *P* = .00). The change in PAI in group 2 was significantly higher than that in group 1 at the 5-year follow-up (independent samples *t* test, *P* = .00) (Table 3). The threshold for bone resorption was previously established at a .04 change in PAI.[6,11]

Overall, change in bone areas was approximately 6.6 and 43.8 mm^2 in groups 1 and 2, respectively. When averaged over the ridge length (44 mm in group 1 and 42.5 mm in group 2), the change in bone areas resulted in an approximate 0.15-mm loss of ridge height (0.03 mm per year) in group 1 and a 1.03-mm loss of ridge height (0.21 mm per year) in group 2 over a mean period of 5 years.

Table 4 Multiple Linear Regression Analysis of All Factors over 5 Years

Variable	Coefficient	Standard error	*t*	*P*	95% confidence interval
Prosthesis type	–0.062	0.018	–3.445	.002	–0.100 to –0.025
Age	0.000	0.002	0.119	.906	–0.003 to 0.003
Ridge length	–0.001	0.003	–0.246	.808	–0.006 to 0.005
Years edentulous	–0.004	0.004	–1.094	.286	–0.014 to 0.004
No. of dentures	–0.002	0.006	–0.336	.740	–0.013 to 0.010
Initial height of mandible	–0.008	0.004	–2.279	.033	–0.015 to –0.001
Relining frequency	0.036	0.013	2.787	.011	0.009 to 0.063

Table 5 Multiple Regression Including Type of Prosthesis, Initial Height of the Mandible, and Relining Frequency Only

Variable	Coefficient	Standard error	*t*	*P*	95% confidence interval
Prosthesis type	–0.057	0.013	–4.323	.000	–0.085 to –0.030
Initial height of mandible	–0.009	0.003	–2.624	.014	–0.015 to –0.002
Relining frequency	0.037	0.011	3.428	.002	0.015 to 0.059

Table 6 Effect of Initial Height of Residual Ridge by Type of Prosthesis

Variable	Coefficient	Standard error	*t*	*P*	95% confidence interval
Group 1	–0.002	0.004	–0.498	.627	–0.012 to –0.007
Group 2	–0.013	0.006	–2.265	.041	–0.026 to –0.001

In the multiple regression analysis, only the type of prosthesis, the initial height of the mandible, and relining frequency were significantly correlated with change in PAI (P = .002, P = .033, and P = .011, respectively; Table 4).

The final model, therefore, contained three factors: type of prosthesis, initial height of the mandible, and relining frequency (Table 5). The effect of group 2 in comparison to group 1 (effect of prosthesis type) was to reduce PAI by 5.7% per year (P = .00). The effect of the initial height of the mandible was such that for every 1-mm increase in the height of the mandible, a reduction of PAI by an extra 0.9% per year was observed (P = .014). For each relining incident recorded, a corresponding reduction in PAI by 3.7% was observed (P = .002). The effects on PAI each year were different in the two groups (Table 6). For group 1, every 1-mm increase in height of the mandible resulted in a 0.2% reduction in PAI per year (P = .627); in group 2, every 1-mm increase in height of the mandible led to a reduction of PAI by an extra 1.3% per year (P = .04).

Discussion

The results of this study should be interpreted with caution since only men were included. Women were conveniently excluded since it appears that the risk of elevated bone resorption resulting from the influence of hormonal factors[6,7] would require a far larger group of patients than this preliminary design permitted. Proportional area measurement in terms of area index (PAI) was used in the present study since it reduces the problems associated with magnification inherent in rotational tomograms in the posterior mandibular region. Such a method is more accurate and comprehensive in determining mandibular alveolar bone resorption than the conventional method on cephalometric radiographs, which was described by Tallgren[12] and modified by Uçtaşli et al.[13] Tallgren's technique[12] measured bone resorption at four selected points only (not the entire area of the ridge) and did not consider the variability in the amount of bone resorption between different sites of the ridge.

After 5 years, the difference in PAI was significant in group 2 when compared with group 1. This finding may be related to the presence of space between the components of the resilient ball attachment, which may permit free vertical rotation of the overdenture during function with concentration of diverse forces on the residual ridge areas. This unrestricted vertical and presumably horizontal movement could result in most of the masticatory load being transferred directly to the posterior edentulous ridge, with minimal stress transmitted to the implants.[14,15] Increased bone loading as a result of this resilient support could then contribute to increased ridge resorption since it interferes with blood circulation in the mucosa and alveolar bone, as well as loading bone unfavorably.

The significant association between bone resorption and relining frequency in group 2 concurred with the findings of Naert et al.[16] They reported that ball anchors were associated with an increased frequency of relining events of the denture base compared to other types of overdenture attachments. The fewer partial overdenture relining frequencies found in group 2 may also be a result of the masking of the posterior mandibular resorption by an increased anterior resorption in the maxilla without provoking occlusal instability of the dentures.[6]

It is tempting to presume that the reduced resorption rates in group 1 could be attributed to the direct metal frame contact with the healing abutments, which provides effective support and prevents denture base rotation. As a consequence of this direct support, the posterior ridge may be protected from excessive loading, with most of the load being transmitted vertically to the implants. The slight bone reduction in group 1 after 5 years may be attributed to the peri-implant alveolar bone loss, which was subtracted from the PAI.

Most follow-up studies on distal extension RPDs have not included measurement of bone resorption beneath the distal extension bases.[17,18] Uçtaşli et al[13] reported a mean 1.15-mm ridge reduction in the posterior mandible after 5 years. A similar amount of bone resorption was reported in this study in group 2 (1.03 mm). However, the study by Uçtaşli and associates[13] was conducted on patients wearing conventional distal extension RPDs.

Finally, evaluation of ridge resorption alone is only part of a prosthodontic patient's clinical outcome. Therefore, additional studies on larger and mixed-gender patient groups that include survival rate of the implants, condition of the terminal abutment teeth, prosthetic maintenance, and patient-mediated outcome concerns are necessary to evaluate the long-term merits of modified treatment modalities such as the one employed in this study.

Conclusions

Within the limitations of this preliminary study's research design, the following conclusions can be drawn with caution, since only men were included:

- Implant-supported partial overdentures appear to be associated with reduced posterior mandibular ridge resorption when compared to implant-retained partial overdentures, since mean ridge height reductions at the end of a 5-year observation period were 0.15 and 1.03 mm, respectively.
- The type of prosthesis design, the mandible's initial height, and relining frequency showed an association with posterior mandibular ridge resorption.

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