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MAXILLARY CHANGES
UNDER CONVENTIONAL DENTURES
OPPOSING MANDIBULAR
IMPLANT-SUPPORTED FIXED PROSTHESSES

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A thesis submitted in partial fulfilment
of the requirements for the

DEGREE OF MASTER OF DENTAL SCIENCE

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University of Sydney

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The aim of this study is to observe changes in the anterior maxilla in subjects rehabilitated with a maxillary conventional denture opposing a mandibular osseointegrated implant-supported fixed prosthesis. The clinical and radiographic findings during the course of this research will be analysed to determine whether there is a significant loss of alveolar bone in the anterior maxilla under the above occlusal scheme.

The results obtained will be used to establish a pattern for such a change, if present, with regard to the age and sex of the subjects and duration of wear of the prostheses. These findings will also be compared with the changes seen in the combination syndrome.
Literature Review
Introduction:

Rehabilitation of an edentulous mouth with conventional dentures restores the facial appearance of the subject, but other aspects of oral function such as biting force and chewing efficiency are restored only to a limited extent. Osseointegrated implants are now used widely in prosthodontic rehabilitation ranging from a single tooth replacement to implant-supported complete dentures, especially for patients with denture adaptation problems.

DeBoer\textsuperscript{1} outlined the following major factors which may be considered for fabricating a particular type of prosthesis:

a) Patient preference
b) Planning
c) Oral hygiene
d) Medical status/health
e) Economics

Dramatic improvement in patient's assessment of their own chewing ability from 2 months post-insertion has been observed on replacing optimal lower conventional dentures with fixed prostheses.\textsuperscript{2} The results were even better after 3 years indicating a gradual adaptation over time.\textsuperscript{3} Improved results in bite force measurements and chewing efficiency/comminution tests have also been observed with such prostheses opposing conventional dentures.\textsuperscript{2}

Biological and prosthodontic improvement led to a very positive response from the patients to their masticatory function and to accepting the prosthesis as part of their body.\textsuperscript{4} Psychological response significantly improved in such patients with an improved quality of life and regained self-confidence.\textsuperscript{5}

The bone and soft tissue surrounding implants have also shown a favourable response to the extent that appreciable improvement in bone density and even bone deposition at
the inferior border of the mandible, where a fixture had perforated, have been reported.\textsuperscript{4,6}

However, few studies have looked at the effect of these prostheses on the opposing prostheses and supporting tissues. Significant loss of anterior maxillary ridge height and features related to combination syndrome have been reported with a maxillary denture opposing an implant-supported overdenture.\textsuperscript{7,8}

The following review of the literature outlines some aspects of alveolar bone physiology and its relationship to:
1) Tooth loss
2) The wearing of prostheses
3) Changes in the maxillary alveolar ridge under conventional dentures against the mandibular natural dentition
4) Changes in the maxillary alveolar ridge under conventional dentures associated with tooth-supported and implant-supported mandibular prostheses

**Physiology of bone remodeling - Changes in mature bony tissue:**

Bone is a specialised connective tissue with load bearing capacity. Its response to forces and function is influenced by a multitude of factors, more so in the jaw bones. Bone tissue is in a state of continuous flux throughout the life of an individual and undergoes remodeling by way of the physiological process of bone apposition and resorption, depending on the activity of osteoblasts and osteoclasts, respectively.\textsuperscript{9-11} Bone adapts to the overlying mechanical stress by remodeling, within physiological limits.\textsuperscript{12,13} Lack of functional stimulation through the periodontal ligaments also leads to a reduction of the bone tissue.\textsuperscript{14} Two mechanisms were proposed to explain localised resorption of bone. One is the piezoelectric nature of bone\textsuperscript{15,16} where mechanical deformation generates electric current. Regions with positive potential showed evidence of osteoclastic activity.\textsuperscript{17} The other mechanism suggested by Justus and Luft,\textsuperscript{18} is the mechanochemical hypothesis according to which strain on bone
alters the solubility of hydroxyapatite crystals, which in turn alters the local activity of extracellular calcium. Bone cells are thus triggered to bring the extracellular calcium to normal level by removing or producing new cells. The role of calcium homeostasis in bone resorption has been well documented.\textsuperscript{19,20} Raisz\textsuperscript{21} hypothesised a reciprocal relationship between extracellular calcium concentration and bone resorption to maintain calcium homeostasis. Extracellular concentration of calcium is controlled by parathyroid hormone and 2,5-dihydroxycholecalciferol (stimulate resorption), and phosphate and thyrocalcitonin (inhibit resorption).

**Alveolar changes following tooth extraction**

Remodeling of the residual alveolar bone occurs after extraction of teeth and is effected by both external and internal changes in the bone.\textsuperscript{22} The resorption of residual ridges appears to be a chronic inevitable process which occurs universally, irrespective of age, sex, sickness, wearing of dentures, and whatever the primary cause for tooth extraction might have been, that is, caries or periodontal disease.\textsuperscript{19,23} Atwood\textsuperscript{22} described the reduction of residual ridges as a pathologic process where the resorption may be so extensive that in certain cases there is no cortical bone covering the crest of the ridge. Fenton\textsuperscript{19} observed that the wearing of dentures increases the resorption of the alveolar ridge and is unaffected by the health of the skeleton.

**Factors influencing post-extraction changes**

Atwood\textsuperscript{24} attributed the reduction of residual ridges to a multitude of co-variables that are in a unique combination in each individual such that the rate of reduction varies from person to person. He categorised these into three types:

a) Availability of viable bone cells, osteoblasts and osteoclasts, which have a shorter life. Possibly, with age, these cells may reduce in number, become less sensitive and perform less work. Although age has not been observed as a factor in bone loss, it may require further investigation.
b) Biochemical factors, which may be local or systemic,
   1) Local factors include endotoxins from plaque, osteoclast-activating factor, prostaglandins, human gingival bone-resorption stimulating factor, heparin and local microorganisms, and toxins leaching from the denture material
   2) Systemic factors such as osteoporosis

c) Physical loads which, in the absence of teeth, are borne by the alveolar bone through the mucoperiosteum. The effect of loading is discussed later in this section.

In a detailed review of factors involved in alveolar ridge resorption presented by Mammen, calcium deficiency, phosphorous imbalance and osteoporosis were cited as the common systemic factors. Trauma to the alveolar ridge caused by a prosthesis, included immediate dentures, ill-fitting dentures, bruxism and night-time wear of the dentures, incorrect vertical dimension of occlusion, the occlusal scheme and occlusal form of teeth.

Kelsey stated that local factors (including biomechanical forces) should be considered of prime significance in the aetiology of residual ridge reduction, while systemic factors (vitamins, minerals and hormones), which equally influence the body as a whole, are secondary. No research was undertaken to verify this phenomenon.

The soft tissue covering of the bone (periosteum) has a profound effect on bone remodeling as the bone has limited capacity to remodel itself. Localised bone resorption has been found to occur as a result of mechanical stress and in the absence of deep infection. Among other factors, greater trauma during extraction of teeth results in greater resorption of the residual ridges.
Pattern of changes in edentulous maxilla:

Jacobs et al\textsuperscript{7} did not find any relationship between the age of the patient and the yearly rate of bone resorption in their study on maxillary bone resorption with different mandibular prostheses.

In the maxilla, shrinkage of the bone usually leads to a narrower arch that is evident from the change in position of the incisive papilla in relation to the anterior alveolar ridge. The reason for such a decrease in the circumference is the oblique orientation of the teeth in the alveolar process which itself is inclined anteriorly and laterally.\textsuperscript{31}

During a randomized cross-sectional study of 300 dried skulls, Cawood and Howell\textsuperscript{32} found that the bone loss in the anterior and posterior maxilla is both vertical and horizontal, from labial and buccal aspects, respectively.

Johnson\textsuperscript{33} carried out a study to ascertain the changes that occurred in the edentulous maxilla during the normal healing period after extraction of remaining teeth, in an otherwise healthy mouth. He found rapid reduction in both the height and the width of the alveolar process which continued for ten to twenty weeks. No changes were observed in the relationship between the palate and the base of skull, from calculations of lateral cephalometric tracings.

Tallgren\textsuperscript{34} reported dimensional stability in the posterior vault of the palate even after 7 years of wearing a complete denture. However, craniofacial structures of aged people did not show any evidence of senile atrophy. In a later study, Tallgren\textsuperscript{35} found evidence of greater bone resorption in cases where increased bite forces were encountered.

Interestingly, dimensions of the middle one-third of face are unaffected by age, loss of teeth and wearing of dentures.\textsuperscript{36} This may imply that minimal changes occur in most of the maxillary bone except for the alveolar process, which undergoes modification and resorption depending upon the abovementioned factors.
Trauma from instability of dentures:

Mechanical trauma from dentures leading to bone loss has been reported in various studies.\textsuperscript{37-39} Maxillary dentures have been observed to exhibit a predominantly horizontal pattern of movement in function as opposed to a more vertical pattern for the mandibular dentures.\textsuperscript{40} This can be related to the pattern of resorption of the anterior maxilla after loss of teeth, mentioned earlier in this section.

Instability of dentures, by way of tilting and shifting over the denture bearing area, has been reported to cause trauma to the supporting tissues and possibly accelerate alveolar bone loss.\textsuperscript{41}

Effect of loading or pressure on alveolar bone:

The magnitude, duration, frequency and distribution of chewing and biting forces are of prime importance in the evaluation of the natural dentition as well as any prosthetic occlusion pattern.\textsuperscript{42}

Frost\textsuperscript{11} described a process resulting from a series of compression, internal hydraulic-like effect, external bulging and external osteoclastic activity followed by narrowing of bone, called “inwaisting”. Thicker, stronger and a greater number of trabeculae were found to resist deformation under load. This was supposed to be a reason for the greater deformation of alveolar bone under compression in the elderly, where a loss in number and thickness of trabeculae leads to increased osteoclastic activity.\textsuperscript{24}

Tension or shear loads on the alveolar bone were found to be detrimental to the health of the alveolar ridge.\textsuperscript{25} Trabeculae oriented perpendicular to the ridge crest would be optimal to resist compression forces under the denture. Excessive mechanical pressure has also been associated with the resorption of residual ridges.\textsuperscript{10}
Dysfunction of the masticatory system decreases the value of bite forces compared with a healthy dentition. Data indicate that bite forces are significantly lower (4 to 5 times) in complete denture wearers compared with people with a natural dentition.

Tallgren observed greater resorption of alveolar bone under a maxillary denture where evidence of higher bite forces was present which possibly caused greater loading of stress bearing areas.

Falk et al studied occlusal force patterns with lower implant-supported fixed bridges and upper conventional dentures in 10 edentulous patients. The ten-unit lower fixed prostheses consisted of bilateral posterior two-unit cantilevers. Axially directed forces were measured with eight evenly placed strain gauge transducers (in supraocclusion) in the upper denture, one against each cantilever unit and the other four placed against the fixture-supported units. The occlusion was carefully adjusted to obtain simultaneous contacts on all transducers. Forces were measured in tapping, maximal habitual occlusion and chewing. Results showed closing and chewing forces increasing posteriorly from mesial to distal transducers. Chewing and light closing forces increased significantly from the distal fixture-supported unit to the first cantilever unit. During maximal closing in habitual occlusion, the increase from the first cantilever unit to the second was also significant. Of the total functional occlusal forces, 40% were borne by the cantilever of the preferred side, 30% by the cantilever of the non-preferred side and 30% by the fixture-supported units. The cantilever, thus bears 70% of the total functional forces. The oral mucosa supporting the maxillary denture is more resilient in the anterior region of the ridge. This resilience probably leads to a larger anterior deflection of the upper denture reducing pressure in the anterior region. The authors suggested using fewer occlusal contacts in fixed prostheses with large cantilevers. The magnitude of functional forces with upper conventional dentures in this study was similar or greater than cases of tooth-supported fixed prostheses with bilateral cantilevers against natural teeth. On an average, only 49% of the maximum closing force were used during regular chewing cycles, ranging from 18% to 73%.
Maxillary complete conventional denture opposing mandibular natural dentition:

Shen and Gongloff\textsuperscript{47} studied a group of maxillary denture wearers with different opposing occlusal schemes. One such group consisted of 21 subjects with natural dentition in the mandible with at least one molar present bilaterally such that no mandibular prosthesis was necessary. Tissue changes seen in the combination syndrome were not observed in this group.

In another group of 7 patients with upper dentures and unilateral mandibular posterior tooth loss, at least distal to second premolar, Shen and Gongloff\textsuperscript{47} observed loss of anterior maxillary bone and hypermobile ridges in 14\% and loss of vertical dimension and periodontal disease in 29\%.

In the same study,\textsuperscript{47} a group of 16 subjects with upper dentures and bilateral missing lower molars (no prosthesis), had periodontal disease (100\%), loss of vertical dimension (88\%), canting of alveolar ridge and tuberosity elongation (56\%), and loss of alveolar bone in the posterior mandible (44\%). Interestingly, 25\% of these patients showed features of combination syndrome even in the absence of a lower denture.
Maxillary complete conventional denture opposing different mandibular prostheses

I. Maxillary complete conventional denture opposing mandibular distal extension removal partial denture:

Kelly\textsuperscript{48} first described the changes observed in a patient with a complete upper denture opposing lower anterior natural teeth and a distal-extension partial denture and coined the term “combination syndrome”. The five characteristic changes constituting this disease entity are:

1) loss of bone from anterior maxillary ridge
2) overgrowth of the maxillary tuberosities
3) papillary hyperplasia in the hard palate
4) overeruption of remaining mandibular anterior teeth
5) resorption of posterior part of lower ridge under the partial denture

The pattern of changes observed are probably initiated by the loss of bone in the anterior maxilla, which is considered to be the least resistant to stress in the maxillary arch. Saunders et al\textsuperscript{49} further attributed the following features to this condition:

1) loss of vertical dimension of occlusion
2) occlusal plane discrepancy
3) anterior spatial repositioning of the mandible
4) poor adaptation of prostheses
5) epulis fissuratum
6) periodontal changes

Shen and Gongloff\textsuperscript{47} observed changes in 25 maxillary denture wearers opposing natural anterior teeth with no molar teeth, of which 9 wore distal extension partial dentures. One out of four subjects showed evidence of alveolar ridge changes similar to combination syndrome. Interestingly, subjects not wearing a prosthesis also showed these changes in the same ratio.
II. Maxillary complete conventional denture opposing mandibular complete conventional denture:

The edentulous ridge bears horizontal, vertical and diagonal forces through a denture bearing surface area which is much less than the periodontium of all the natural teeth. Also, the wearing of dentures is invariably accompanied by an undesirable, but extremely variable, bone loss.50

Jacobs and co-workers7 observed annual maxillary bone resorption that was greater under complete dentures compared with patients wearing implant-supported overdentures.

In contrast with the above, Douglass et al51 reported insignificant loss of alveolar bone in the maxillary ridges of 24 complete denture patients over a twenty-year period.

In a ten-year longitudinal study by Tuncay et al52 of 37 complete denture patients, resorption of the maxillary residual ridges was found to be insignificant. This is contrary to another study where resorption of both the ridges has been reported, though mandibular resorption was about four times that of the maxillary ridge.35 These authors reported rotation of the maxillae in a counterclockwise direction in the sagittal plane, with a forward movement of the upper denture. They also observed that the seating of dentures exceeded the amount of bone resorption in all the cases, indicating that the dentures were bedding down into the soft tissue corresponding to the change in position of the dentures. Variables such as age, sex, night-time wear and fabrication technique were not found to be significant, although skeletal pattern and period of edentulousness were considered factors affecting prognathism and mandibular ridge resorption.

Tallgren35 observed a pronounced reduction of the pre-extraction morphologic face height after wearing complete dentures for 7 years and a less marked reduction in postural (rest) face height. Also, the average reduction in anterior height for the
maxillary alveolar ridge over a period of 25 years was found to be 2.5-3 mm., almost four times less than that for the mandible.

Glantz and Stafford$^{53}$ evaluated bite forces and functional loading levels in maxillary complete dentures in a group of satisfied and dissatisfied complete denture wearers. They concluded that dissatisfied patients may have problems in chewing foods efficiently, while at the same time there may be local high-stress levels at the denture-supporting tissue interface which may influence the increased tendency for bone resorption and mucosal inflammatory reactions seen in complete denture wearers.

**Immediate dentures:**

A group of 12 immediate denture wearers was compared with a group of 10 subjects who were given dentures after healing.$^{30}$ Changes were studied over a period of 2½ years in the central incisor region with respect to the buccal and vertical dimensions. Slightly less resorption was observed in the immediate denture wearers, which was not statistically significant. The differences between the two groups diminished with time and at the end of the observation period were negligible.

Carlsson et al.$^{39}$ also reported similar observations with no significant differences regarding resorption in the two groups, but they suggested greater chances for the reformation of a continuous bone plate on the labial surface in the immediate denture wearing group. Age, sex and size of the alveolar process were not found to significantly affect the bone resorption.$^{39}$
III. Maxillary complete conventional denture opposing mandibular implant-supported overdenture:

Lechner and Mammen\textsuperscript{8} studied thirteen patients wearing an upper conventional denture and a lower implant-supported overdenture for at least 3 years, to assess the fit of the maxillary denture, occlusal integrity and changes in anterior maxillary residual ridge. They reported significant loss of bone in the anterior maxilla, loading of the maxillary ridge anteriorly and loss of occlusal contacts posteriorly. All subjects presented with soft tissue hyperplasia in the anterior maxilla. The majority (11/13) of the patients observed progressive loosening of the upper dentures. These findings are similar to those reported in combination syndrome situations.

A limited but continuing maxillary bone resorption was observed in patients with such a prosthodontic scheme, although increased anterior maxillary resorption was not observed,\textsuperscript{7} which contrasts with other studies summarised here. Jacobs et al\textsuperscript{7} also observed a linear relationship between the anterior maxillary bone resorption and the time from placement. This relationship was observed in both the overdenture and the fixed denture group. However, no such correlation was seen in the posterior maxilla.

Changes similar to combination syndrome were also observed in subjects rehabilitated with a maxillary conventional denture opposing a transmandibular implant-supported overdenture.\textsuperscript{54,55}
IV. Maxillary conventional denture opposing mandibular implant-supported fixed prosthesis:

Jacobs et al.⁷ used radiographic tracings from orthopantomograms modifying the area index method for the lower jaw as described by Wilding et al.⁶⁶ A slightly higher annual maxillary bone resorption was observed in 12 patients with mandibular implant-supported fixed prostheses compared with a mandibular implant-supported overdenture group.⁷ These subjects had been edentulous for at least two years. They also observed a direct linear relationship between the resorption in the anterior maxilla and the period of time when implants were first placed. However, no such correlation could be established in the posterior maxilla.

Fifteen patients with edentulous mandibles were treated with osseointegrated implant-supported fixed bridges by Henry et al.⁶ and twelve wore a conventional denture in the maxilla. Clinical results of a 10-year follow-up study of these subjects did not find any evidence of the development of flabby ridges in the anterior maxilla as may be evident of combination syndrome-like features. Increased bone loss in this region was also not observed on intra-oral periapical radiograph (parallel cone technique) and orthopantomograph evaluation. This is in contrast with the results reported by Jacobs et al.⁷ The authors relate this to a vertically stable upper denture and thus a more stable occlusion. Seven maxillary dentures were remade, including 2 remakes for one patient for aesthetics, and 3 were relined during the study.

Zarb & Schmitt⁷⁷ observed 46 patients treated with implant-supported prostheses for a period of 4 to 9 years, of which 40 had a mandibular implant-supported fixed bridge. They did not observe a need for relines or the development of midline fractures of the opposing maxillary dentures, thereby negating the belief that the incidence of ridge resorption increases in these cases due to an increase in bite force. However, radiographic or clinical assessment to support this claim was not presented in this study.
Stafford and co-worker\textsuperscript{58} studied deformation of maxillary dentures opposing lower implant-supported fixed bridges in 7 dissatisfied complete denture wearers. They placed 5 linear strain gauges on the oral and mucosal surfaces of the upper denture. There was a marked improvement in biting and chewing efficiency after treatment with implant-supported fixed prostheses in the mandible. However, loading of the upper denture did not increase following this treatment. This is significant, as no risk of complications associated with loading should be observed.

Lindquist et al\textsuperscript{4} observed 46 edentulous patients with denture adaptation problems treated with mandibular implant-supported fixed prostheses for a period of 46 to 66 months. Amongst the maxillary denture wearers, they encountered 20 midline fractures in 14 patients, relining required for 13 dentures and new dentures were fabricated in 4 cases.

Hemmings et al\textsuperscript{59} observed 25 mandibular implant-supported fixed bridges opposing maxillary complete dentures for a period of 5 years. They reported 6 incidences of the need for reline or remake of the upper denture, but no fractures.
Summary of Literature Review

Resorption of alveolar bone following tooth loss and the wearing of different prostheses has been widely studied. The loss of bone is considered to be inevitable, although the magnitude varies amongst patients and in the same patient at different regions and at different times. Host resistance has, therefore, been accepted as the limiting factor in bone resorption.\textsuperscript{7,22,30,35,60-62}

Combination syndrome has been shown to be a sequel of the tissueward movement of the distal extension base of the mandibular partial denture opposing a maxillary conventional denture.\textsuperscript{47,48}

A similar effect has also been reported with a maxillary conventional denture opposing a mandibular implant-supported overdenture\textsuperscript{7,8} as well as opposing a transmandibular implant-supported overdenture.\textsuperscript{54} The mechanics of these two types of prostheses is similar to a distal extension partial denture, in terms of the potential for tissueward movement during function.

Few studies have been performed for implant-supported fixed bridgework on edentulous mandibles opposing maxillary complete dentures, to evaluate the functional forces involved and the effect on the maxillary ridge.

Opinion is divided over the functional forces borne by the maxillary denture opposing implant-supported fixed bridges. Loading forces were not found to increase as reported by Stafford et al.\textsuperscript{58} On the other hand, Falk and co-workers\textsuperscript{45} measured closing and chewing forces comparable to partially restored natural dentitions. Greater forces were observed in the posterior region of the maxillary denture opposing the cantilever units of the implant prosthesis. Greater resilience of the anterior maxillary ridge was supposed to allow upward deflection of the upper denture anteriorly and absorb much of the forces. As a direct consequence of higher functional forces in such situations, midline fracture of the upper denture as well as increased incidence of relines and remakes is reported in a few studies.\textsuperscript{4,6,59} However, Zarb and Schmitt\textsuperscript{57} opposed this
view and did not encounter midline fractures or the need for reline of the upper dentures in 40 patients with similar prostheses.

A difference of opinion is also evident in two studies investigating anterior maxillary bone loss under complete dentures opposing implant-supported fixed bridges. Jacobs et al.\textsuperscript{7} reported increased bone loss, while Henry et al.\textsuperscript{6} did not observe bone loss and flabby ridges in the anterior maxilla.

This study was undertaken to further assess whether there is a significant loss of alveolar bone in the edentulous anterior maxilla under a conventional denture opposing a mandibular implant-supported fixed prosthesis. Results obtained would be used to establish a pattern for such a change, if present, with regard to age and sex of the subjects, and duration of wear of the prosthesis.
Methods
Eleven edentulous subjects rehabilitated with a mandibular osseointegrated implant-supported fixed prosthesis and a maxillary complete conventional denture at the Implant Centre, United Dental Hospital, Sydney, Australia were selected for this study. The sample included 4 males and 7 females, their ages ranging from 53 to 74 years (mean-65.64 yrs.) (Table 1). They had been wearing these prostheses for at least 21 months. Their records did not show evidence of any systemic factors which might effect bone loss, such as osteoporosis, deficiency of calcium and vitamin D, excessive phosphorous and parathyroid hormone.  

Formal approval for the proposed study was obtained from the Human Ethical Review Committee of the United Dental Hospital prior to commencement. WHO approved International Ethical Guidelines for Biomedical Research Involving Human Subjects (Geneva 1993) were followed. This requires obtaining Informed Consent from prospective subjects involved in the project.

Subject information statement explaining the purpose of the study, procedures to be carried out and duration of the appointment was written in plain language and mailed to the prospective subjects (Appendix I). It was stated that the present dentures and implants would be evaluated including radiographs to monitor bone loss. Suitable appointments would be made for any maintenance work that may be necessary. Those subjects willing to participate were to sign the consent form provided and return it in a stamped-addressed envelope enclosed with the form. An appointment was made over the telephone once their approval was received for inclusion in the study. At the start of the appointment, the subject was informed about the purpose and procedures involved in the study. The appointments were carried out in the Implant Centre and the Department of Clinical Dentistry at the United Dental Hospital.
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<td>08/06/95</td>
<td>20/08/98</td>
<td>3-02</td>
<td>13/06/96</td>
<td>2-02</td>
</tr>
<tr>
<td>MK</td>
<td>F</td>
<td>63</td>
<td>25/03/92</td>
<td>02/09/98</td>
<td>6-05</td>
<td>02/03/83</td>
<td>15-06</td>
</tr>
<tr>
<td>FB</td>
<td>F</td>
<td>53</td>
<td>N A</td>
<td>11/06/97</td>
<td>N A</td>
<td>15/03/91</td>
<td>6-03</td>
</tr>
</tbody>
</table>
History:

A questionnaire prepared for this study was filled out by the operator for each subject (Appendix II). On the top page, personal details of the subject, medical status, number and type of implants, dates of implant and abutment placement and fabrication of definitive prostheses were recorded.

Each subject's opinion about his/her prostheses was assessed by asking if they were "satisfied with their upper dentures". In case of a negative response, the reason was noted. They were asked to grade their present "chewing ability" from the time of implant treatment as being the same, better or poorer. Occurrences of remakes, repairs and adjustments of the upper denture, at the Implant Centre or outside, were recorded.

Clinical Examination:

The maxillary denture was removed and the alveolar ridge examined clinically. The anterior maxilla was palpated using a cotton bud or ball burnisher to detect any evidence of hypermobile or flabby tissue (Fig. 1). The status of the ridge was recorded as firm or flabby (Table 2).

Stability and Retention:

The maxillary denture was seated in the mouth and checked for stability and retention using conventional procedures for complete dentures.30

Stability was checked by seating the denture firmly in the mouth, placing the index fingers in the premolar region and gently trying to rotate the denture in the horizontal plane. Ideally, there should be no movement during this procedure. Stability was recorded as adequate or poor.
Fig. 1: Flabby maxillary ridge
Retention was checked in the anterior and posterior parts of the palate. The denture was firmly seated and gently pulled down by the incisors to check for anterior retention. For posterior retention, the denture was firmly seated and light finger pressure applied on the lingual aspect of the incisors in an upward and forward direction to break the posterior palatal seal. Resistance observed in this movement suggested adequate retention. Retention was recorded as adequate or poor for both anterior and posterior regions.

**Fit of the Denture:**

The fit of the upper denture was evaluated using a pressure disclosing paste- Fit-checker. The amount of material was standardized by having the length of the bead of base paste equal to the anteroposterior length of the denture, while the catalyst paste was half this measure.

In each case, the fit was disclosed twice, once under moderate finger pressure and once under moderate biting pressure.

1) Finger Pressure: The upper denture, with fit checking material, was seated on the denture bearing surface. Index fingers were placed on either side, midway anteroposteriorly, to seat the denture and maintain moderate pressure until the material was set.

2) Biting Pressure: The upper denture, with fit checking material, was seated on the denture bearing surface. The subject was asked to bite with moderate force and maintain until the material was set.

Photographs were taken of the tissue-fitting surface of the upper denture with the set disclosing material in place in both instances (Figs. 2 & 3). Visual differences in the thickness between the two disclosing impressions, especially in the anterior part of the ridge, were noted.

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*GC Corp. Japan
Fig. 2: Maxillary denture with pressure disclosing paste under finger pressure

Fig. 3: Maxillary denture with pressure disclosing paste under biting pressure
Occlusion:

Prostheses for all subjects were made by two clinicians. At the time of issue of the implant-supported prosthesis, all posterior teeth were in occlusion. The aim of this clinical exercise was to evaluate the state of occlusion at the present time. The discrepancy between the upper and lower teeth in the posterior region on both the sides was to be measured.

Records and impressions were taken at the time of the appointment as detailed below. All measurements were carried out on articulated casts in the laboratory.

The impression of the upper denture was made in a stock tray using alginate impression material.*

The space between the lower bridge and the mucosa underneath was blocked out with blue utility wax to prevent the impression material flowing under the bridge and tearing on removal, causing distortion of the impression. The impression of the lower prosthesis was also made using alginate impression material.

Both the impressions were poured in yellow dental stone.† The cast of the maxillary denture (Cast A) was duplicated (Cast B) using a reversible hydrocolloid mould.

To record the centric relation, the denture teeth were not allowed to contact when the subject closed their mouth, so that the effect of the present occlusion would be nullified.

*Jeltrate, Dentsply USA
†Investo, Boral Australia
Fig. 4: Occlusal stops on the maxillary denture

Fig. 5: Dentures occluding on occlusal stops with a gap of 1-2 mm between teeth
Occlusal stops made in Type I low fusing green impression compound* were placed in
the premolar region on both sides of the upper denture (Fig. 4) and the patient guided
into centric relation. Jaw closure was limited by a gap of 1-2 mm. between the upper
and lower teeth when the subject occluded on the stops (Fig. 5).

The compound stops were chilled and the upper denture was reseated in the mouth.
Ramitec bite registration paste† was mixed and syringed over the occlusal surface of
the mandibular teeth. The mandible was gently guided to close on the stops in centric
relation. It was held in this position until the paste was set (Fig. 6). The set record was
gently eased from the teeth.

The original face bow transfer record of the maxillary denture cast, attached to an
articulator mounting plate, was obtained from the Implant Centre. The interocclusal
transfer record was fitted over the new mandibular prosthesis cast in the laboratory.
The maxillary face bow transfer was fitted onto the interocclusal record-mandibular
cast assembly. This assembly was sealed with the help of metal rods and sticky wax
and articulated on a semi-adjustable Denar articulator. The maxillary assembly was
removed from the articulator after the plaster was set.

Maxillary Cast A was placed on the interocclusal transfer record-mandibular cast
assembly, sealed and articulated as above at the original face bow relationship. When
the plaster was set, Cast A, with its mounting plate, was unscrewed from the
articulator.

Maxillary Cast B was held against the mandibular cast in the position of maximum
intercuspation. The casts were sealed and articulated in this position (Figs. 7 & 8). This
represented the present occlusion. Blue articulating paper‡ was placed on both sides
and marks obtained for occlusal contacts (Fig. 9). The most posterior mark would be
used as the point of reference for the discrepancy between the upper and lower teeth.

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*Kerr Corp.
†ESPE, West Germany
‡Bausch Dental Co., USA
Fig. 6: Dentures occluding on compound stops with bite registration paste
Fig. 7: Maxillary Cast B hand articulated in intercuspal position

Fig. 8: Maxillary Cast B hand articulated in intercuspal position – close-up view
Fig. 9: Articulation paper marks showing the most posterior contact mark
Maxillary Cast B was replaced by Cast A on the articulator. A small amount of Luxatemp™ was placed over the lower posterior teeth on both sides covering the most distal contact mark. The articulator was closed until the teeth were in contact (Figs. 10 & 11). When the Luxatemp had set, the articulator was opened and the set block of Luxatemp eased off the cast. The blue articulating paper marks had been transferred onto the block (Fig. 12). The most distal mark was identified and the thickness measured (in mm.) at this point by means of callipers† (Fig. 13). The measurements were recorded for both left and right sides for each subject.

---

†DMG, Germany
‡R Johnsson, Sweden
Fig. 10: Maxillary Cast A in occlusion with Luxatemp over the posterior contact mark

Fig. 11: Maxillary Cast A in occlusion with Luxatemp over the posterior contact mark – close-up view
Fig. 12: Block of Luxatemp with the most posterior contact mark

Fig. 13: Measuring the thickness at the most posterior contact mark
Cephalometric analysis:

One subject was not included in the cephalometric analysis as the post-operative cephalograph was not available. This analysis was carried out for only 10 subjects.

A thin strip of lead film was waxed to the mesial half of the labial surface of the left central incisor on the upper denture to outline the position of the upper incisor in the radiograph. Lateral head cephalographs were taken with the dentures in occlusion at the Radiology Department of the United Dental Hospital, Sydney. One set of radiographs was recorded following abutment placement (Post-operative cephalograph) during the prosthodontic phase of the implant-supported fixed bridge treatment. A similar radiograph was taken at the present appointment (Follow-up cephalograph) in the same department. A copy of these radiographs was used for the purpose of this study.

The cephalographs were analysed using the system outlined by Scott, Barber and Maxson\textsuperscript{63} for the vertical and horizontal measurements of the edentulous maxilla. The relevant landmarks were located and traced on the tracing paper as per this system for both the post-operative and the follow-up radiographs (Fig. 14).

The vertical and horizontal measurements were calculated from the tracings of both radiographs for each subject. The values obtained for the follow-up radiograph were subtracted from those of the post-operative radiograph to obtain the effective change during the observation period. These values were divided by the observation period (in years) to determine the annual bone resorption in the anterior maxilla for each subject. The observation period was the time interval between the two dates when the post-operative and follow-up cephalographs were taken. This observation period (Table 1) ranged from 2.42 to 11.0 years (mean- 5.16 years). The observation period is different from the duration of denture wear, which is the period since the maxillary denture was issued.
Mean and standard deviation were calculated for all the measurements. Student’s t test (two-tailed paired means comparison) was used to statistically evaluate bone loss and check the significance (95% confidence level) of the resulting values in this group. Simple regression analysis was used to determine a linear relationship between the annual bone loss against the age of the subject and duration of wear of the prosthesis.

Radiographs were not taken by the same operator and on the same cephalostat due to different periods of observation for each subject. However, as recommended by Scott et al, tracings for both the post-operative radiograph and the follow-up radiograph were made by the same examiner to minimise tracing errors. The subject’s identity was not known to the examiner and the radiographs were traced randomly. Those of the same subject were not traced simultaneously. This was to prevent the examiner from being unduly influenced by the expected results in the follow-up tracings.
Landmarks:

ANS - Anterior nasal spine
PNS - Posterior nasal spine
ANS-PNS - Palatal plane
C-point - Most anterior-inferior point on maxilla
C-line - Line passing through C, perpendicular to palatal plane
C'-point - Represents the intersection of palatal plane and C-line
E'-point - Point 10 mm. posterior to C'-point along the palatal plane
E-line - Line passing through E'-point perpendicular to palatal plane
E-point - Most inferior maxillary point along the E-line
D-line - Line passing through ANS perpendicular to palatal plane
C-D line - Line passing through C-point parallel to palatal plane
D-point - Represents the intersection of D-line and C-D line

Measurements:

Vertical measurements
1) C to C'
2) E to E'

Horizontal measurements
1) ANS to PNS
2) ANS to C'
3) C to D

Fig. 14: Landmarks and points for cephalometric evaluation
Results
Subject's assessment of the fit of the upper denture:

Eight subjects (72.7%) found their upper denture satisfactory in terms of the fit, while two complained of loosening of the denture (Table 2). One subject observed that the upper denture “seems to be going up in the front and down at the back”.

The upper denture was relined for 1 subject once, approximately one year ago, and the present denture felt loose again. A new upper denture was made for 1 subject 5 years ago. The upper denture had been remade 3 times and relined 3 times for 1 subject over six years. The subject reported that the present upper denture was the “most successful so far”.

Status of the maxillary anterior ridge:

Flabby tissue in the anterior region of the maxillary alveolar ridge was palpated in 7 subjects (63.6%). The mucosa was relatively firm in the other 4 subjects (36.4%). There was no evidence of flabby ridge in the subject wearing the prostheses for 10 years in this study (Table 2).

Retention and stability of the upper denture:

The operator assessed the retention of the upper denture to be adequate in 9 subjects (81.8%). The stability of the denture was also found to be adequate in 9 subjects (81.8%). Retention and stability were observed to be poor in 1 subject. One subject had poor retention but adequate stability, while another exhibited adequate retention but excessive lateral rocking of the upper denture (Table 2).
<table>
<thead>
<tr>
<th>Subject</th>
<th>Flabby ridge</th>
<th>Assessment of Maxillary Denture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Retention</td>
</tr>
<tr>
<td>SM</td>
<td>Absent</td>
<td>Adequate</td>
</tr>
<tr>
<td>RH</td>
<td>Present</td>
<td>Adequate</td>
</tr>
<tr>
<td>EM</td>
<td>Absent</td>
<td>Poor</td>
</tr>
<tr>
<td>BH</td>
<td>Present</td>
<td>Adequate</td>
</tr>
<tr>
<td>LH</td>
<td>Absent</td>
<td>Adequate</td>
</tr>
<tr>
<td>EL</td>
<td>Present</td>
<td>Poor (rocking)</td>
</tr>
<tr>
<td>LW</td>
<td>Present</td>
<td>Adequate</td>
</tr>
<tr>
<td>NH</td>
<td>Present</td>
<td>Adequate</td>
</tr>
<tr>
<td>DH</td>
<td>Absent</td>
<td>Adequate</td>
</tr>
<tr>
<td>MK</td>
<td>Present</td>
<td>Adequate</td>
</tr>
<tr>
<td>FB</td>
<td>Present</td>
<td>Adequate</td>
</tr>
</tbody>
</table>
Evaluation of fit of the upper denture:

The thickness of the film of Fit-checker in the upper denture was visually evaluated. It revealed a thinner film of material in the anterior region when the subject occluded against the lower prosthesis (Fig. 3), compared with the situation when the denture was held under finger pressure by the operator (Fig. 2). This was observed in all 11 subjects.

Posterior occlusion:

A loss of posterior occlusion was observed on one or both sides of the denture in all the subjects (Table 3). This ranged from 0 to 2.5 mm on the left and 0 to 2.0 mm on the right side of the prosthesis. A maximum discrepancy of 2.5 mm on the left and 2.0 mm on the right sides was observed in one subject (Figs. 15 & 16), while the remainder were 1 mm or less. The values were different on the two sides for 10 subjects (90.9%). The discrepancy was the same on both the sides in only one subject.
Fig. 15: Occlusal discrepancy between the posterior teeth

Fig. 16: Occlusal discrepancy between posterior teeth – close-up view
Table 3: Opening between maxillary and mandibular teeth at the most distal point of contact (in mm.)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Left side (in mm.)</th>
<th>Right side (in mm.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>RH</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>EM</td>
<td>0.2</td>
<td>1.0</td>
</tr>
<tr>
<td>BH</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>LH</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>EL</td>
<td>0.0</td>
<td>0.6</td>
</tr>
<tr>
<td>LW</td>
<td>0.3</td>
<td>0.9</td>
</tr>
<tr>
<td>NH</td>
<td>0.2</td>
<td>1.0</td>
</tr>
<tr>
<td>DH</td>
<td>0.4</td>
<td>0.9</td>
</tr>
<tr>
<td>MK</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>FB</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Max.</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Min.</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Cephalometric evaluation:

As stated earlier in the methods, the post-operative cephalograph was not available for one subject, who showed the maximum loss of occlusion in this study. The cephalometric evaluation was, therefore, performed for only 10 subjects.

Vertical measurements:

C-C':
Bone loss was measured in 4 subjects (40%), ranging from 1 to 4 mm. No change was observed in post-operative and follow-up values in 3 subjects (Table 4). An increase in value by 1 mm was observed in 3 subjects (30%). A mean annual bone loss for the group was calculated at 0.17 mm. The difference was not found to be statistically significant (p>0.05).

E-E':
Bone loss was calculated in 6 subjects (60%), ranging from 1 to 4 mm. 4 subjects (40%) showed no change (Table 5). A mean annual bone loss of 0.29 mm was calculated. The difference was found to be statistically significant (p<0.05).
Table 4: Vertical Maxillary Measurements - C - C'

<table>
<thead>
<tr>
<th>Subject</th>
<th>Post-op values</th>
<th>Follow-up values</th>
<th>Net loss</th>
<th>Observation period (yrs.)</th>
<th>Annual bone loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>7.33</td>
<td>0</td>
</tr>
<tr>
<td>RH</td>
<td>14</td>
<td>15</td>
<td>-1</td>
<td>5.50</td>
<td>-0.1818</td>
</tr>
<tr>
<td>EM</td>
<td>12</td>
<td>13</td>
<td>-1</td>
<td>4.67</td>
<td>-0.2141</td>
</tr>
<tr>
<td>BH</td>
<td>14</td>
<td>13</td>
<td>1</td>
<td>5.00</td>
<td>0.2000</td>
</tr>
<tr>
<td>LH</td>
<td>15</td>
<td>15</td>
<td>0</td>
<td>11.00</td>
<td>0</td>
</tr>
<tr>
<td>EL</td>
<td>9</td>
<td>8</td>
<td>1</td>
<td>2.42</td>
<td>0.4132</td>
</tr>
<tr>
<td>LW</td>
<td>20</td>
<td>16</td>
<td>4</td>
<td>3.00</td>
<td>1.3333</td>
</tr>
<tr>
<td>NH</td>
<td>14</td>
<td>14</td>
<td>0</td>
<td>3.10</td>
<td>0</td>
</tr>
<tr>
<td>DH</td>
<td>14</td>
<td>13</td>
<td>1</td>
<td>3.17</td>
<td>0.3155</td>
</tr>
<tr>
<td>MK</td>
<td>10</td>
<td>11</td>
<td>-1</td>
<td>6.42</td>
<td>-0.1558</td>
</tr>
</tbody>
</table>

Mean 12.8000 12.4000 0.4000 5.16 0.1710
Std. Dev. 3.8239 3.2040 1.506 0.4593

't' value 0.84
p value p>0.05

(All measurements in mm.)
Table 5: Vertical Maxillary Measurements - E - E'

<table>
<thead>
<tr>
<th>Subject</th>
<th>Post-op values</th>
<th>Follow-up values</th>
<th>Net loss</th>
<th>Observation period (yrs.)</th>
<th>Annual bone loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>7.33</td>
<td>0</td>
</tr>
<tr>
<td>RH</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>5.50</td>
<td>0</td>
</tr>
<tr>
<td>EM</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>4.67</td>
<td>0.2141</td>
</tr>
<tr>
<td>BH</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>5.00</td>
<td>0.2000</td>
</tr>
<tr>
<td>LH</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>11.00</td>
<td>0.0909</td>
</tr>
<tr>
<td>EL</td>
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<td>3</td>
<td>1</td>
<td>2.42</td>
<td>0.4132</td>
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<td>LW</td>
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<td>7</td>
<td>4</td>
<td>3.00</td>
<td>1.3333</td>
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<tr>
<td>NH</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>3.10</td>
<td>0</td>
</tr>
<tr>
<td>DH</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>3.17</td>
<td>0.6309</td>
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<td>MK</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>3.42</td>
<td>0</td>
</tr>
</tbody>
</table>

Mean 5.7000 4.7000 1.0000 5.16 0.2883
Std. Dev. 2.5408 1.947 1.2470 0.4229

't' value 2.535
p value p<0.05

(All measurements in mm.)
Horizontal measurements:

ANS-PNS:
Bone loss was observed in 6 subjects (60%), ranging from 1 to 4 mm. 4 subjects (40%) showed no change in values (Table 6). A mean annual bone loss was calculated at 0.32 mm. The difference was found to be statistically significant (p<0.05)

ANS-C':
Loss of bone in the posterior direction (horizontal plane) was observed in 4 subjects (40%), ranging from 2 to 3 mm (Table 7). Anterior movement of the crest of the ridge was observed in 3 subjects (30%), ranging from 1 to 4 mm. No change was observed in 3 subjects (30%). A mean annual posterior repositioning of the crest of the ridge was calculated at 0.02 mm. The difference was not found to be statistically significant (p>0.05).

C-D:
The measurements were the same as ANS-C' for all the subjects.
Table 6: Horizontal Maxillary Measurements - ANS - PNS

<table>
<thead>
<tr>
<th>Subject</th>
<th>Post-op values</th>
<th>Follow-up values</th>
<th>Net loss</th>
<th>Observation period (yrs.)</th>
<th>Annual bone loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>51</td>
<td>51</td>
<td>0</td>
<td>7.33</td>
<td>0</td>
</tr>
<tr>
<td>RH</td>
<td>51</td>
<td>47</td>
<td>4</td>
<td>5.50</td>
<td>0.7273</td>
</tr>
<tr>
<td>EM</td>
<td>54</td>
<td>53</td>
<td>1</td>
<td>4.67</td>
<td>0.2141</td>
</tr>
<tr>
<td>BH</td>
<td>54</td>
<td>52</td>
<td>2</td>
<td>5.00</td>
<td>0.4000</td>
</tr>
<tr>
<td>LH</td>
<td>54</td>
<td>54</td>
<td>0</td>
<td>11.00</td>
<td>0</td>
</tr>
<tr>
<td>EL</td>
<td>60</td>
<td>57</td>
<td>3</td>
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<td>1.2397</td>
</tr>
<tr>
<td>LW</td>
<td>57</td>
<td>57</td>
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<td>NH</td>
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<td>52</td>
<td>1</td>
<td>3.10</td>
<td>0.3226</td>
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<tr>
<td>DH</td>
<td>56</td>
<td>55</td>
<td>1</td>
<td>3.17</td>
<td>0.3155</td>
</tr>
<tr>
<td>MK</td>
<td>51</td>
<td>51</td>
<td>0</td>
<td>3.42</td>
<td>0</td>
</tr>
</tbody>
</table>

Mean: 54.1000  52.9000  1.2000  5.16  0.3219
Std. Dev.: 2.9230  3.0350  1.3980  0.3998

‘t’ value: 2.714
p value: p<0.05

(All measurements in mm.)
Table 7: Horizontal Maxillary Measurements - ANS - C'

<table>
<thead>
<tr>
<th>Subject</th>
<th>Post-op values</th>
<th>Follow-up values</th>
<th>Net loss</th>
<th>Observation period (yrs.)</th>
<th>Annual bone loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>6</td>
<td>9</td>
<td>-3</td>
<td>7.33</td>
<td>-0.4093</td>
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<tr>
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<td>3</td>
<td>4</td>
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<td>0.7273</td>
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<td>5</td>
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<td>4.67</td>
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<tr>
<td>BH</td>
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Mean 6.3000 6.5000 -0.2000 5.16 -0.0166
Std. Dev. 1.4944 2.4152 2.3944 0.4770

't' value -0.2640
p value p>0.05

(All measurements in mm.)
Discussion
The results of this study suggest that the anterior segment of the maxillary alveolar ridge does not exhibit increased resorption under a maxillary conventional denture when occluding with a mandibular osseointegrated implant-supported fixed prosthesis.

The loss of posterior occlusion observed does not appear to be the result of bone loss in the anterior maxillary region. Compared with a lower implant-supported overdenture against an upper denture, a fixed prosthesis would show minimal deflection of the cantilever segment. Any loss of posterior occlusal contact could thus be due to the tissueward deflection of the upper denture and would point towards a loss of alveolar height in the posterior region of the maxillary ridge. Cephalometric evaluation technique used in this study, however, did not evaluate measurements in the posterior segment.

Another reason for the posterior loss of occlusal contact may be the wear of acrylic teeth. Rarisch reported a loss of 0.1 mm due to abrasion of acrylic teeth in the first two years of complete denture use and was followed by an annual loss of 0.1 mm for the subsequent period. Ogle and Davis observed a 0.214 mm average wear of acrylic teeth over a period of 3 years, which was greater for maxillary teeth as compared with mandibular teeth. All subjects in this study had acrylic resin teeth in their dentures. The difference in occlusal discrepancy between the two sides may be explained on the basis of the preferred chewing side of the subject. Visual comparison of the original casts to the present prosthesis showed wear in some of the cases, though no attempt was made to evaluate any dimensional change in the acrylic teeth. One subject did observe that the denture teeth seemed to be worn. A periodic review of the occlusion, therefore, is a significant factor in the maintenance of implant-supported prostheses and an annual appointment schedule should at least be followed for the life of the prosthesis.

The incidence of flabby maxillary ridges was observed in the majority of the cases. However, there is no documentation of the absence or presence of this feature at the time of issue of the implant-supported prosthesis. This development, therefore, cannot be attributed with certainty to the particular occlusal scheme.
Pressure disclosing paste did reveal a greater amount of force in the anterior region on biting in all subjects, although bone loss and flabby ridges were not observed in all cases.

No evidence of fracture of the maxillary denture was reported either in the subject’s record or by the subject. There was one incidence of reline of the maxillary denture for one subject, while one upper denture was remade for another. However, one subject had a number of relines and remakes of the upper denture, but is now satisfied with the present denture.

The radiographic evaluation indicates that the vertical measurements at the crest of the maxillary ridge (C-C’) are nearly even in distribution between bone loss, no change and increase in height of the ridge. The identification of ANS point is difficult due to the thin isthmus of bone with greater superimposition of soft tissue and poor quality of the radiograph. There seems, however, to be a significant reduction in the length of the palatal plane (ANS-PNS) as well as in the height of the anterior maxilla (E-E’) posterior to the crest of the ridge. The horizontal change observed is probably due to the posterior repositioning of the anterior nasal spine that may be related to the age of the subject and the pressure exerted by the maxillary denture. The crest of the ridge is known to move posteriorly due to the pattern of resorption, which shifts the E’ point along the palatal plane due to the posterior repositioning of the C-line. The palatal contour narrows, from the crest posteriorly, in the superoinferior dimension, and this supports the significant reduction in the E-E’ dimension. The posterior shift of both the D-line and the C-line explains the insignificant change observed in the ANS-C’ dimension. A linear relationship could not be established for annual vertical bone loss with respect to the age and sex of the subjects and duration of wear of the prosthesis. It would have been interesting to compare the changes in the subject who showed maximum occlusal loss, but the post-operative cephalograph was not available.

Post-operative lateral cephalographs were not taken at the time of issue of the mandibular prosthesis. In some cases, the radiograph had been taken more than a year before the subject started using the prostheses. The annual bone changes have been
calculated for the interval between the two sets of radiographs (observation period) and not for the duration of denture wear, although the dentures were worn for the majority of this period.

Errors in this study could be attributed to the quality of radiographs, difficulty in identifying radiographic landmarks and problems associated with radiographic tracing. The operator and the cephalostat were not the same for all subjects.
Conclusion
The rehabilitation of an edentulous subject with a mandibular implant-supported fixed prosthesis occluding with a maxillary complete conventional denture appears to be a successful mode of treatment with respect to changes in the anterior maxillary alveolar ridge.

Loss of alveolar bone in the anterior maxilla and resulting development of a flabby ridge cannot be attributed to such a prosthodontic scheme.

Loss of posterior occlusion should, however, be accepted as a sequel to such treatment, especially with opposing acrylic teeth.

Periodic recall appointments to review the occlusion are of prime importance to maintain occlusal harmony and the health of the supporting tissues. The treatment is bound to deteriorate if the occlusion is not checked and corrected on an annual basis.

Future research could include a larger sample size to provide a clearer picture as well as study changes in the posterior maxilla with such a prosthodontic scheme. The use of porcelain teeth in implant-supported complete dentures could overcome problems associated with acrylic teeth, but needs further study.
Appendix I

Subject Information Statement and Consent Form
THE UNIVERSITY OF SYDNEY
FACULTY OF DENTISTRY

IMPLANT FOLLOW UP RESEARCH PROGRAM

The discipline of Prosthodontics, University of Sydney is currently researching bone response in jaws opposing an implant supported bridge. We would like you to be part of that research.

As part of a normal check up procedure we will ask you some questions about your upper denture and your lower bridge. We will also check your dentures and implants, and take X-rays to monitor any bone resorption which may be occurring. This visit should take around an hour. If maintenance work needs to be carried out we will inform you and make a suitable appointment.

If you are willing to help us by allowing us to use your records as a basis for this very important research, please sign your consent form below and return it to us in the envelope supplied. We will then contact you to make a mutually suitable appointment.

Thank you very much.

I agree to participate in the research program outlined above. I understand that complete confidentiality will be maintained and I will not be identified in any published or unpublished papers resulting from this research. I may also withdraw from this project at any time without penalty or prejudice.

__________________________  _______________________
Signature of participant        Date

__________________________  _______________________
Signature of clinician          Date
Appendix II

Questionnaire Regarding the Prostheses
Questionnaire

1) Are these the upper dentures made for you at the time of Implant treatment for the lower jaw?

2) Are you satisfied with the upper dentures? If not, why?

3) How do you grade your chewing ability as compared to the initial period when implant treatment was done? Same, better than before, poorer?

4) Do you have any other problem with your dentures?

5) If yes, when did you notice this first?

6) Is there any change in the condition now?

7) Were any adjustments made by a dentist?
References


DEAR PROF. LECHNER,

Thank you for guiding me so patiently through the maze.

With kind regards

Suvash Gupta
22nd Dec. 1998
Memorandum

To: CSAHS Ethics Review Committee

From: Adj: Assoc. Professor N A Duckmanton
      Assoc. Professor S K Lechner

Date: 12 August 1999

Subject: Project 3/97 Dr S Gupta

This is to certify that Dr Gupta's research project No. 3/97, entitled "Maxillary Changes under Conventional Dentures Opposing Implant Supported Fixed Prostheses", has been carried out in strict compliance of which the original protocol and all of its aspects have been observed.

The raw data is contained in the patients' files which are kept under the normal file security observed at the United Dental Hospital.

Access to this data would be made in accordance with the normal rules governing access to patient data, in force at the above institution.

Signed

1. S K Lechner
   MDS FRACDS FICD FPFA
   Assoc. Professor
   Head of Department of Prosthodontics
   Faculty of Dentistry
   University of Sydney
   Prosthodontist

2. Signed

   N A Duckmanton
   RFD MDS FRACDS
   Adj: Assoc. Professor
   Faculty of Dentistry
   University of Sydney
   Prosthodontist
   Chief Investigator