

# Effects of Mandibular Fixed Implant-Supported Protheses on Masticatory and Swallowing Functions in Completely Edentulous Elderly Individuals

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**Purpose:** To evaluate the effect of oral rehabilitation with immediately loaded fixed implant-supported mandibular protheses on chewing and swallowing in elderly individuals. **Materials and Methods:** Fifteen completely edentulous patients aged more than 60 years (10 women and five men), wearing removable dentures in both arches, had a mandibular denture replaced by an implant-supported prosthesis. All individuals were evaluated before surgery and again 3, 6, and 18 months later with regard to mastication and swallowing conditions. Examinations entailed an interview, evaluation of tactile sensitivity of the face, and observation of food intake, masticatory type, formations of bolus, and pain during mastication. The swallowing evaluation comprised observation of clinical signs related to the oral and pharyngeal stages of swallowing, as well as the presence of oral residue. The findings of different evaluations before and 3, 6, and 18 months after the surgical-prosthetic procedure were statistically compared by analysis of variance for repeated measurements at a significance level of 5%. **Results:** The questionnaire revealed a reduction in complaints of masticatory and swallowing disturbances, a decreased need for liquid ingestion, and reduced choking and coughing. Clinical evaluations showed improved oral function and bolus propulsion for both solid and paste-consistency foods; pain during mastication was also resolved. **Conclusion:** Treatment with mandibular implant-supported dentures had positive effects on the clinical aspects of mastication and swallowing in elderly individuals. INT J ORAL MAXILLOFAC IMPLANTS 2009; 24:110–117

**Key words:** complete denture, elderly, implant-supported protheses, mastication, swallowing

Swallowing is the result of the synchronized and coordinated action of several groups of muscles involving the oral cavity, pharynx, larynx, and esophagus, whose movements are controlled by the central

nervous system and integrated by sensorial stimuli and peripheral motor actions.<sup>1,2</sup> The swallowing process changes physiologically with aging, involving modifications in the oral mucosa, reductions in alveolar bone, decline in the number of functional motor units, and weakness and muscle atrophy.<sup>3</sup> In addition, changes in tongue function caused by aging impair suction and swallowing,<sup>4</sup> with clear damage to swallowing coordination in elderly individuals.<sup>5</sup> These changes cause difficulties in the oral control of food boluses, premature escape of food to the pharynx, pharyngeal dysfunction, abnormalities in the pharyngo-esophageal segment, and motor disturbances in the esophagus.<sup>6</sup> Thus, individuals with a reduced number of teeth may show damage to their masticatory<sup>7</sup> and swallowing functions, with a higher frequency of laryngeal penetration, as observed in edentulous elderly subjects compared to dentate individuals.<sup>8</sup>

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According to the literature, jaw stabilization by occlusion on posterior teeth or prostheses is important in the swallowing function.<sup>9</sup> Conversely, the duration of preparatory and oral swallowing stages is reduced in the presence of complete dentures in edentulous elderly individuals.<sup>10</sup> If prostheses with insufficient vertical dimension are worn, there is reduced space for the tongue, leading to inadequate tongue posture and contraction of the perioral musculature during swallowing.<sup>11</sup>

Implant-supported oral rehabilitation, in comparison with removable dentures, allows individuals to resume masticatory performance similar to that observed in individuals with natural dentition,<sup>12</sup> in addition to improving biting force,<sup>13-16</sup> without statistically significant differences in food intake and type of mastication, as well as contraction of the perioral musculature and tongue thrusting during swallowing.<sup>17</sup> It should be highlighted that such studies have not been conducted in elderly individuals.

Therefore, this study evaluated the effect of oral rehabilitation with immediately loaded fixed implant-supported mandibular prostheses on chewing and swallowing in individuals over 60 years old, who generally present with a higher frequency of dental problems and oropharyngeal neuromuscular disturbances.

## MATERIALS AND METHODS

### Patients

Fifteen patients were selected for this prospective study, with a minimum age of 60 years, from the clinics of Maxillofacial Surgery and Traumatology, Prosthodontics, and Implantology at the Dental School of University of Sagrado Coração, Bauru, Brazil. During selection, all patients submitted to an interview and specific clinical dental and speech-language evaluation. The study was approved by the Institutional Review Board of the University of Sagrado Coração on March 12, 2003, under protocol no. 001/2003.

All individuals were completely edentulous, had worn removable complete dentures for at least 6 months, and presented good clinical conditions of the maxillary arch and different situations with regard to bone quality. In an attempt to achieve a homogeneous sample and better prognosis, all patients were required to have a mandibular bone structure that allowed the use of implants with a minimum length of 10 mm. Included patients also exhibited good general health.

The exclusion criteria comprised individuals with parafunctional habits; physical or cognitive limita-

tions that might interfere with the ability to perform regular oral hygiene; localized inflammatory process or oral pathologies, either untreated or currently being treated; high risk of subacute infectious endocarditis; uncontrolled diabetes or bone metabolic disorders; coagulation disturbances or anticoagulant therapy; presence of renal insufficiency or hepatic pathology; immune disorders; steroid treatment in the previous 2 years at a dose equivalent to 20 mg of hydrocortisone for 2 weeks or longer; ongoing chemotherapy; history of radiotherapy for treatment of head and neck neoplasia; history of neurologic, psychologic, or psychiatric diseases; smoking; and abnormal jaw relationship, such as mandibular prognathism or retrognathism. The present exclusion criteria were based on the reports of Barewal et al<sup>18</sup> and Testori et al.<sup>19,20</sup>

### Surgical and Prosthetic Procedures

Before surgery, the conditions of maxillary and mandibular complete dentures worn by the patients were evaluated. Dentures that were considered inadequate were replaced and evaluations were performed at least 6 months after the placement of new dentures.

After this step, the patients were submitted to the surgical protocol, which comprised the placement of five endosseous implants of 4-, 4.5-, or 5-mm diameter in the mandibular arch. Eight patients received screw-type self-tapping cylindrical implants with smooth machined surfaces, and seven patients received screw-type self-tapping conical implants with acid-treated surfaces (all implants 3i/Implant Innovations Inc, Palm Beach Gardens, FL).

Before completion of implant placement and suturing, the initial stability of implants was measured by resonance frequency analysis using the Osstell device (Integration Diagnostics, Göteborgsvagen, Sweden). Abutments were fixed to the implants. If a minimum value of 60 Hz was reached, indicating sufficient stability to load the implants immediately, procedures for preparation, finishing, polishing, and fitting of prostheses were then performed. The time interval between insertion of implants and placement of prosthesis was less than 24 hours. The complete dentures previously worn by the patients were converted to an implant-supported prosthesis.

Sutures were removed after 7 days; patients were evaluated during this period for occlusal adjustment, if required. Dentures were maintained in place for 3 months. After this period, the dentures were removed for observation of connections and then reinserted.

## Interview and Orofacial Myofunctional Evaluation

Clinical evaluation of subjects was performed at four periods: immediately before surgery (Pre) and 3, 6, and 18 months after surgery (Post1, Post2, and Post3, respectively). This comprised an interview and physical examination. Testing and was performed by a single examiner.

The interview addressed aspects directly related to masticatory and swallowing functions. The following questions were presented to the patients (yes/no responses):

- Do you have difficulties in chewing food?
- Do you have difficulties in swallowing food?
- Do you ingest liquids to help with swallowing?
- Do you choke during meals?
- Do you have coughing after meals?
- Do you clean your throat (phlegm) after meals?

Tactile sensitivity of the external surfaces of cheeks, lips, and chin was evaluated as to recognition of the type and location of stimuli applied. Cotton swabs and toothpicks were used for evaluation of extraoral sensitivity; the patient was to locate and recognize the stimulus. Cheeks were stimulated externally on the midpoint between the lip commissure and tragus. The upper and lower lips received the aforementioned stimuli externally on the midpoint between the philtrum and lip commissure. The tactile stimuli were also applied at the mental protuberance region. The response was considered adequate when the individual was able to locate and recognize the stimuli applied.

For evaluation of mastication, the patients received a slice of bread approximately 1 cm in width. The analysis addressed the pattern of food intake as follows: use of the anterior teeth (characterized as normal) versus use of the lateral teeth, tearing the bread with the hands, or tearing the bread with the teeth and hands (characterized as abnormal).

The masticatory type was evaluated by visual counting of the number of masticatory cycles performed by individuals. Patients were scored as chronic unilateral if nearly 95% of actions occurred on the same side (adapted from Tay<sup>21</sup>). A simultaneous bilateral pattern (in which the food is chewed on both sides) and alternate bilateral pattern (in which the food is alternately positioned on each side) were considered as normal; only the chronic unilateral type was considered inadequate.

To evaluate patients' ability to form a food bolus, when the patients reported that mastication was complete, they were asked to retract the lips so that the evaluator could observe the formation of a

homogeneous bulk on the longitudinal tongue groove. Upon completion of mastication, the patient was also asked about the presence of pain during chewing.

With regard to swallowing, the performance of patients was investigated by use of foods with different consistencies. A paste consistency (puddinglike consistency) was achieved by mixing 100 mL of diet grape juice and 3 scoops of thickener (Nutilis, Support, Advanced Medical Nutrition, Sao Paulo, Brazil); water was used for liquid consistency, and bread was used to represent solid-consistency food.

The following aspects were observed for solid, paste, and liquid foods during swallowing:

- Lip sealing, observed subjectively as the ability to keep the lips constantly sealed (considered normal), performance of nonsystematic lip sealing/nonsystematic opening of the lips, or absence of lip sealing (lips constantly open).
- Time of bolus propulsion, represented by the duration of posterior propulsion of the food bolus by the tongue before swallowing. Normality was established subjectively, especially by observation of movements of the suprahyoid muscles up to the laryngeal elevation. This aspect was considered altered when the process was slow.
- Oral residue, for which the patient was asked to open the mouth after swallowing. This aspect was considered altered in the presence of any food residue, regardless of location and quantity.
- Presence and amplitude of laryngeal elevation, evaluated by the examiner keeping the second finger on the submandibular region and the third finger on the hyoid bone; laryngeal elevation of nearly 2.20 cm (close to two finger widths of the examiner) was considered adequate.<sup>22</sup>

The following aspects related to possible penetration and/or laryngotracheal aspiration of food were also considered.

- Cervical auscultation, determined with the aid of a stethoscope placed on the lateral aspects of the laryngeal region during the different swallowing stages, as well as after completion, during prolonged inspiration and expiration. Alterations were considered present whenever noises were detected during auscultation.
- Presence or absence of breathing alterations, during or after swallowing, characterized by changes in the frequency of inspiration/expiration cycles or noisy breathing.
- Changes in facial color, characterized by paleness or cyanosis during or after swallowing.

**Table 1** Percentage of Individuals with Disturbances Recorded in Interviews before (Pre) and at 3 (Post1), 6 (Post2), and 18 (Post3) Months After Implant-Supported Oral Rehabilitation

	Pre	Post1	Post2	Post3	Statistical comparisons
Masticatory disturbances	86.7 <sup>b</sup>	26.7 <sup>a</sup>	20.0 <sup>a</sup>	26.7 <sup>a</sup>	Pre × Post1 ( $P = .002$ ) Pre × Post2 ( $P = .001$ ) Pre × Post3 ( $P = .002$ )
Swallowing disturbances	40.0 <sup>b</sup>	6.7 <sup>a</sup>	0.0 <sup>a</sup>	0.0 <sup>a</sup>	Pre × Post1 ( $P = .019$ ) Pre × Post2 ( $P = .008$ ) Pre × Post3 ( $P = .008$ )
Ingestion of liquid	33.3 <sup>b</sup>	13.3 <sup>ab</sup>	13.3 <sup>ab</sup>	6.7 <sup>a</sup>	Pre × Post3 ( $P = .040$ )
Choking	46.7 <sup>b</sup>	20 <sup>a</sup>	6.7 <sup>a</sup>	13.3 <sup>a</sup>	Pre × Post1 ( $P = .019$ ) Pre × Post2 ( $P = .003$ ) Pre × Post3 ( $P = .008$ )
Phlegm	33.3 <sup>b</sup>	26.7 <sup>ab</sup>	20.0 <sup>ab</sup>	0.0 <sup>a</sup>	Pre × Post3 ( $P = .019$ )
Coughing	13.3	6.7	0.0	0.0	NS

Different letters indicate statistical differences between periods.

- Presence or absence of vocal alterations. The patient was asked to speak the phoneme in an extended manner, before and after swallowing. Perceptive-auditory analysis of the emissions was performed to check for the presence of alterations, such as worsening and hoarseness of the voice after swallowing.
- Presence or absence of coughing before, during, or after swallowing.

The number of swallowing cycles required was also assessed; this aspect was analyzed by counting the number of laryngeal elevations performed to swallow each portion of food. One to three swallows were considered as adequate for all consistencies of food.

### Data Analysis

Statistical analysis of the qualitative variables of the interview and orofacial myofunctional clinical evaluation was performed by analysis of variance for repeated measurements between the Pre, Post1, Post2, and Post3 periods. A significance level of 5% was adopted for all tests.

## RESULTS

The following results correspond to the findings in 15 elderly individuals (10 women and five men) aged 60 to 76 years, with a median age of 64 years.

As demonstrated in Table 1, all complaints related to masticatory and swallowing difficulties presented by individuals in the present study were considerably reduced after implant-supported oral rehabilita-

tion in the mandibular arch. Most parameters exhibited a statistically significant difference ( $P < .05$ ).

Extraoral sensitivity was adequate for all individuals before surgery and after 18 months. Temporary changes were observed in four (26.7%) individuals at 3 months ( $P = .040$ ) and in one individual (6.7%) at 6 months after placement of implants, respectively.

Table 2 displays the results of evaluation of masticatory function. The masticatory type was unilaterally chronic for more than half the subjects at Pre and Post1, decreasing without statistically significant differences at 6 months after placement of implant-supported prostheses. Disturbances in the formation of food bolus were significantly different between 3 and 6 months after surgery ( $P = .04$ ); pain upon mastication was reduced at all postoperative periods compared to the preoperative period ( $P < .05$ ).

Tables 3 to 5 present the evaluations of swallowing of solid, paste-consistency, and liquid foods, respectively. The time of bolus propulsion was reduced for both solid ( $P = .003$ ) and paste-consistency foods ( $P = .004$ ); for solid foods, oral residue was more prevalent after 3 months ( $P < .05$ ) but returned to normal values thereafter. For all consistencies, no individual presented clinical signs of respiratory alterations or changes in face color during swallowing during the different study periods.

## DISCUSSION

The high occurrence of masticatory difficulties related to the use of unstable prostheses and aging problems has been described.<sup>7</sup> Different solutions have been proposed, with varying outcomes.

**Table 2 Percentage of Individuals with Masticatory Difficulties Before (Pre) and at 3 (Post1), 6 (Post2), and 18 (Post3) Months After Implant-Supported Oral Rehabilitation**

	Pre	Post1	Post2	Post3	Statistical comparisons
Food intake	66.7	53.3	33.3	46.7	NS
Type of mastication	66.7	66.7	46.7	33.3	NS
Formation of food bolus	33.3 <sup>ab</sup>	40.0 <sup>b</sup>	13.3 <sup>a</sup>	26.7 <sup>ab</sup>	Post1 × Post2 ( <i>P</i> = .040)
Pain upon mastication	33.3 <sup>b</sup>	0.0 <sup>a</sup>	0.0 <sup>a</sup>	0.0 <sup>a</sup>	Pre × Post1 ( <i>P</i> = .040) Pre × Post2 ( <i>P</i> = .019) Pre × Post3 ( <i>P</i> = .019)

Different letters indicate statistical differences between periods.

**Table 3 Percentage of Individuals with Disturbances in Swallowing of Solid Food Before (Pre) and at 3 (Post1), 6 (Post2), and 18 (Post3) Months After Implant-Supported Oral Rehabilitation**

	Pre	Post1	Post2	Post3	Statistically significant difference
Lip sealing	13.3	0	0	0	NS
Time of bolus propulsion	46.7 <sup>b</sup>	13.3 <sup>ab</sup>	0 <sup>a</sup>	6.7 <sup>a</sup>	Pre × Post2 ( <i>P</i> = .003) Pre × Post3 ( <i>P</i> = .003)
Laryngeal elevation	20	6.7	0	0	NS
Cervical auscultation	13.3	13.3	0	6.7	NS
Coughing	6.7	0	0	6.7	NS
Vocal alteration	0	0	0	0	NS
No. of swallows	66.7	86.7	40	53.3	NS
Oral residue	40 <sup>a</sup>	80 <sup>b</sup>	20 <sup>a</sup>	26.7 <sup>a</sup>	Pre × Post1 ( <i>P</i> = .008) Post1 × Post2 ( <i>P</i> = .000) Post1 × Post3 ( <i>P</i> = .009)

Different letters indicate statistical differences between periods.

**Table 4 Table 4 Percentage of Individuals with Disturbances in Swallowing Paste-consistency Foods Before (Pre) and at 3 (Post1), 6 (Post2), and 18 (Post3) Months After Implant-Supported Oral Rehabilitation**

	Pre	Post1	Post2	Post3	Statistically significant difference
Lip sealing	20	0	0	0	NS
Time of bolus propulsion	26.7 <sup>b</sup>	13.3 <sup>ab</sup>	5.7 <sup>a</sup>	13.3 <sup>ab</sup>	Pre × Post2 ( <i>P</i> = .040)
Laryngeal elevation	6.7	6.7	0	6.7	NS
Cervical auscultation	26.7	13.3	5.7	13.3	NS
Coughing	6.7	0	0	6.7	NS
Vocal alteration	0	6.7	0	13.3	NS
No. of swallows	80	86.7	73.3	73.3	NS
Oral residue	0	0	0	0	NS

Different letters indicate statistical differences between periods.

**Table 5 Percentage of Individuals with Disturbances in Swallowing Liquids Before (Pre) and at 3 (Post1), 6 (Post2), and 18 (Post3) Months After Implant-Supported Oral Rehabilitation**

	Pre	Post1	Post2	Post3	Statistically significant difference
Lip sealing	13.3	13.3	6.7	0	NS
Time of bolus propulsion	0	0	0	0	NS
Laryngeal elevation	13.3	6.7	0	0	NS
Cervical auscultation	60	40	26.7	26.7	NS
Coughing	20	6.7	6.7	6.7	NS
Vocal alteration	6.7	20	6.7	13.3	NS
No. of swallows	80	86.7	73.3	80	NS
Oral residue	0	0	0	0	NS

Implant-supported prostheses are an important treatment option. In addition to this, the research about masticatory and swallowing functions is rare and focuses on mixed age groups.<sup>12-17</sup>

After rehabilitation with implant-supported prostheses, the individuals in the present study showed statistically significant improvements in masticatory and swallowing difficulties at all time periods, in agreement with the results of Grandmont et al,<sup>23</sup> Pêra et al,<sup>14</sup> Mellas et al,<sup>24</sup> Allen and McMillan,<sup>25</sup> Awad et al,<sup>26</sup> and Morais et al,<sup>27</sup> who also reported positive outcomes regarding the mastication of foods of different consistencies following treatment with implant-supported dentures. According to van Kamper et al,<sup>16</sup> the significant improvement in masticatory efficiency provided by implants enhances the swallowing process because of the smaller size of particles to be swallowed. Similarly, Morais et al<sup>27</sup> compared the dietary habits of individuals who submitted to different prosthetic treatments (conventional prostheses and implant-supported prostheses) and found that individuals rehabilitated with implants tended to have fewer swallowing difficulties and needed to ingest fewer liquids during meals, as was observed in the present study.

Individuals in the present sample exhibited significant reduction in choking at all postoperative periods compared to the preoperative condition; the occurrence of phlegm was also improved between the Pre and Post3 periods. The reports of choking and phlegm during eating may be explained by the presence of residues in the larynx and pharynx because of reduced laryngeal raising, as well as increased time of bolus propulsion in the pharynx<sup>28</sup> associated with the laryngeal penetration found in edentulous elderly individuals.<sup>8</sup> Placement of implants solved the difficulties related to the unstable mandibular denture, benefiting oral motor control and the subsequent stages of swallowing. This corroborates studies that observed a relationship between the presence of residues in the pharynx and the status of dentures worn by elderly individuals,<sup>29</sup> as well as the fact that tongue movement responsible for propulsion of the food bolus is directly related to the effectiveness of swallowing.<sup>30</sup>

With regard to facial sensitivity, no alterations were observed at the preoperative period, although the literature indicates a deficit in oral perception in elderly individuals.<sup>5</sup> There was alteration in extraoral sensitivity in some patients at 3 months after treatment, which may be related to manipulation of the alveolar branch of the trigeminal nerve during surgery.<sup>31,32</sup> This process probably represented spontaneous physiologic recovery since, by the time of the third postoperative evaluation, the symptoms had resolved in all affected individuals.

Statistical analysis of masticatory function revealed transient changes in bolus formation; this may be attributed to the sensorial alteration presented by individuals at this period. According to Ono et al,<sup>33</sup> the decline of masticatory performance influences bolus formation; the difficulties in formation of food bolus observed in this study may be attributed to the instability of removable complete dentures in the maxillary arch, whose use does not provide adequate masticatory function<sup>34</sup> because of the imbalance between coordination and sensorimotor function caused by palatal coverage of maxillary removable dentures.<sup>35</sup> No significant changes were found in food intake and type of mastication in the present study, as also reported by Sansone et al<sup>17</sup> who observed that surgical-prosthetic treatment is insufficient to modify the masticatory pattern of individuals. Conversely, the present rehabilitation procedure provided statistically significant reduction in the presence of pain during chewing for all individuals, in agreement with Szentpetery et al,<sup>36</sup> who found that a fixed prosthesis is more effective in diminishing problems than complete dentures.

Among the aspects investigated by clinical examination of swallowing of foods of different consistencies, few signs of dysphagia were observed before placement of implants, such as deficient lip sealing, reduced laryngeal raising, and presence of coughing, cervical auscultation and vocal alteration after swallowing, in accordance with Zamir et al,<sup>37</sup> who found that overall coordination between protection and the transit aspect of the oral-pharyngeal phase of swallowing is preserved in elderly individuals. Long-term evaluation after placement of fixed prostheses revealed that most problems were solved, yet in a non-significant manner, whereas some individuals retained their preoperative performance. No studies were found in the literature investigating signs and symptoms of dysphagia in elderly individuals rehabilitated with implant-supported prostheses; most studies have addressed only the functional improvement related to mastication in adults,<sup>12-16,38,39</sup> ie, formation of smaller food particles to enhance the swallowing process.<sup>16</sup>

Conversely, improved time of bolus propulsion after treatment was observed during swallowing of solid and pastelike foods. This aspect was statistically better for both solid and paste consistencies, which may be attributed to the improved masticatory efficiency<sup>16</sup> as well as to the stability of implant-supported prostheses, which results in better neuromuscular coordination.<sup>40</sup>

The presence of oral residue was increased, with a statistically significant difference only for solid foods, probably because of sensorial alterations, since the motor responses are influenced by sensitive afferent

information.<sup>3</sup> Masticatory efficiency was also improved with the use of fixed prostheses.<sup>12,41</sup> Similar changes were also observed in vocal alterations for liquid foods and the number of swallowing actions for solid foods, although without statistical significance; studies on larger samples might further elucidate these findings.

## CONCLUSION

The present results indicate a general improvement in mastication and swallowing conditions after placement of implant-supported mandibular fixed prostheses in elderly individuals, which was statistically significant ( $P < .05$ ) for the complaints of masticatory and swallowing disturbances, including choking. Clinical examination revealed reduced time of bolus propulsion and oral residue for solid foods.

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