CLINICAL EVALUATION OF THE EFFICACY OF SOFT ACRYLIC DENTURE COMPARED TO CONVENTIONAL ONE WHEN RESTORING SEVERELY RESORBED EDENTULOUS RIDGE

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ABSTRACT

The prosthodontist encounters increasing problems in the fabrication of a well functioning complete denture over a resorbed edentulous ridge. The objective of this study was to clinically evaluate the efficacy of the soft acrylic denture compared to conventional one when used to restore a severely resorbed ridge. Both quantitative and qualitative parameters were assessed. Quantitative parameters were bite force and chewing efficiency (velocity), which was measured 1 week, 3 and 6 months follow-up period, as well as retention force. This latter was recorded after 6 months. Qualitative parameters included denture fit, tissue condition, denture satisfaction, denture complaint and chewing ability. These parameters were assessed after 1 week and 6 months. Eleven subjects were included in the study. They first received conventional dentures. These latters were then substituted with duplicate dentures processed from soft heat cured acrylic resin materials. Results revealed non-significant difference between both types of denture among chewing ability and efficiency of soft food, stability scores, tissue response and satisfaction rate. Chewing efficiency of hard food and bite force showed significant difference in favor to conventional type. Retention force differed significantly in favor to conventional type in mandibular dentures. Conversely, soft acrylic dentures recorded high significant value in maxillary dentures. Moreover, they showed higher significant score of complaint among both conventional upper and soft lower dentures. It was concluded that soft acrylic denture had a better retention of the upper denture, good tissue response, acceptable chewing efficiency and ability, moderate stability scores and high rates of patients’ satisfaction. Therefore it could solve the problem of severely atrophic ridge especially in maxilla and should be considered a treatment option according to patients’ behavior and ridge nature and quality.

INTRODUCTION

Functional problems associated with edentulousness such as loose dentures and diminished chewing efficiency, had been reported by many authors\(^1,2\). The consequences of edentulousness include disability to speak and eat, reduction of social contact and inability of the residual ridge and its overlying tissues to withstand masticatory forces\(^3,4\). Loading of the mucosa overlying
the mandibular bone may occur during swallowing, mastication or clenching via the denture. The mucosa is sandwiched between the denture base and the underlying bone so that all the forces generated by the mandible, during function and parafunction, are transmitted through this atrophic tissue\(^4\). Extreme resorption of the maxillary denture-bearing area may lead to problems with prosthetic rehabilitation\(^5\).

Almost one third of the edentulous patients have complaints from their complete denture especially with regard to their lower one\(^6\). The complaints include insufficient stability and retention of the denture and pain during mastication. With time, as the resorption of the residual ridge was commenced, pain and difficult oral functioning may even increase to an extent that proper nutritional intake and the patient’s ability to communicate with ease and confidence are jeopardized. In addition, a less attractive facial appearance, difficulty with speech and avoidance of social contact may result in psychosocial problems\(^7\). From the patient’s point of view, denture satisfaction appears to be primarily related to aesthetics, retention and function.

A high level of patient satisfaction, when fabricating complete dentures, should be the primary goal in the treatment of edentulous patients. There are 3 key principal factors; retention, stability and support, in the prescription and provision of successful complete dentures\(^8\)-\(^10\). It was stated that complete denture are made up of 3 surfaces; the impression, the polished and the occlusal surfaces\(^11\). The retention, stability and support of the dentures are governed by the design of these surfaces\(^8\)-\(^10\).

The influence of adhesive and cohesive forces, surface tension, atmospheric pressure, viscosity and volume of saliva, gravity, muscle posturing and occlusion on denture retention had been well documented\(^12\)-\(^15\). Denture retention is understood to be a function of saliva surface tension, its viscosity, the thickness of the salivary film, the contact surface and the saliva denture contact angle. Therefore, Kikuchi et al., 1999\(^16\) mentioned that good adaptation of the denture to the tissues, could improve denture retention. A logical consequence of adequate denture retention is less functional movement and better stability\(^17\). Relative lack of sufficient retention of a complete mandibular denture, even if there anatomic landmarks exist, can test the limits of the most skilled and experienced practitioner\(^18\). Occasionally, it is not possible to achieve optimal denture retention and stability because of factors not influenced by adequate denture fabrication alone\(^19\). These factors include poor jaw and ridge relationships, psychologic conditions, neuromuscular coordination, inadequate quantity and poor location of available bone and alveolar mucosa, and inadequate vestibular depth. When conventional complete denture therapy and sound Prosthodontic principles result in inadequate denture retention and stability, patient satisfaction, confidence and comfort commonly suffer\(^19\).

There are treatment alternatives that aid in increasing retention and stability when conventional denture therapy is inadequate. These include resilient denture liner materials or surgical intervention. The liner materials were applied to the intaglio surface of dentures to achieve more equal force distribution, reduce localized pressure and improve denture retention by engaging undercuts\(^20\),\(^21\). The surgical intervention include, augmentation and destriction of the alveolar ridge\(^22\),\(^23\) increase the vestibular depth (vestibuloplasty and lowering the floor of the mouth)\(^24\) and dental implant to provide an anchorage for implant supported/retained prostheses\(^25\).

These facts indicate that problems reported by edentulous patients will continue to challenge dentists, particularly as the ability to adapt to conventional complete dentures that decreases with age\(^26\). The prospective aim of this study was to evaluate clinically soft acrylic denture used to restore a severely resorbed ridges in completely edentulous patients. Objectively, the chewing efficiency, the occlusal bite force and the retention force were measured. Subjectively, the retention and stability scores (denture fit), tissue conditions scores, denture satisfaction rate and chewing ability scores were assessed using validated self-administrated questionnaires focusing problems with related complaints and problems with chewing different types of food\(^27\)-\(^29\).
MATERIALS AND METHOD

Eleven completely edentulous male patients were selected from the Prosthodontic Clinic, Faculty of Dentistry, Menia University.

Inclusion and exclusion criteria:

The patients were selected according to the following criteria:

- Age ranging from 45-55 years.
- Free from any systemic or neuromuscular disorder that might affect chewing efficiency of masticatory muscles.
- Free from any temporo-mandibular joint disorder.
- Class I Angle’s ridge relationship.
- Patient with abnormal tongue behavior and/or size were excluded.
- Patient with xerostomia or excessive salivation were excluded.
- Patient were selected with resorbed ridges in both arches but with firm Mucoperiosteum Fig. (1).
- Patient selected who had been edentulous for at least 1 year.

Conventional complete dentures were identically fabricated in compliance with a neutrocentric philosophy of treatment. Alginate impressions (Alginate chroma done, Ultradent products Inc. Jordan) were made for both ridges, poured into stone plaster. Acrylic special trays were constructed. Border molding with green sticky compound (Kerr Italia S.P.A. 1-84014 Scafti, Salerno-Italia) and final impression for upper and lower ridges were made by using zinc-oxide and eugenol impression material (Cavex outline impression paste (eugenol free) cavex. Holland) to obtain the master cast. Occlusion blocks on the final casts were constructed. A face bow record was made to mount the upper cast on a semiadjustable articulator\(^{(30)}\) Fig. (2).

![Fig. (1): Completely edentulous patients with severe resorbed ridges. (a) Mandibular ridge, (b) Maxillary ridge](image1)

Centric occluding relation was recorded at the accurate vertical dimension of occlusion, using check bite technique to mount the lower cast on the articulator in centric relation.\(^{(30,31)}\) Protrusive record was made to adjust horizontal condylar guidance of the articulator, while the lateral condylar guidance was adjusted according to the equation \(L=H/8+12\) (Hanan formula). Zero- degree posterior denture teeth (Acrylic cross-linked, Acrostone, Egypt) were set on a flat plane over the ridge crest and the anterior teeth were set without vertical overlap\(^{(27)}\). Waxing-up of denture base was then performed. Try-in
was made and the occlusion was carefully checked on the articulator as well as in the patient mouth. Occlusion was verified both in centric and eccentric positions.

Face bow index for the waxed-up upper trial denture base was done to be used for clinical remounting and latter on for soft acrylic denture construction. Fig. (3).

Waxed up denture was flasked, packed and cured with conventional heat cured acrylic resin material (Acrostone WHW plastic England packed by Anglo Egyptian Lab). The conventional acrylic resin denture was processed in a water bath curing tank for 1½ hour at 74°C and another 1 hour at 100°C. Then, the dental flask was cooled to room temperature. Denture was laboratory remounted, finished and polished.

All patients routinely worn their prostheses. Clinical remounting was done to refine the finished denture occlusion on the articulator. The upper cast was remounted by aid of face bow index, while the lower cast was remounted by making new centric relation record. Also, horizontal condylar guidance was re-adjusted by wax-wafer protrusive record. Subsequently lateral condylar path inclination was calculated from Hanan formula.

Then, the finished denture was checked for proper extension, retention and stability intra-orally. The patient was given a proper program for denture insertion and oral hygiene measures. The patient was recalled after 48 hours to check for any pressure area causing pain or discomfort. Each patients was allowed to wear his denture for one week during which complete settling and adaptation of the denture could occur. Hence, duplication of the denture was performed once the first set of dentures was seemed to be comfortable by the patient, producing another set of denture with soft acrylic resin type. The dentures had their intaglio, polished and occlusal surfaces were replicated as accurately as possible using the following method. The definitive casts were duplicated using reversible hydrocolloid (Polyflex; dentsply, York, pa) and mounted in the same relationship as the original final casts. The original set of denture was used to produce matrices in vinyl polysiloxane (Sherasil, Werkstoff. Technologic GmbH & Co KG, Lemforde, Germany). These matrices were used to fabricate maxillary and mandibular autopolymerizing acrylic resin bases (vertex; Dental BV, Zeist, the Netherlands) with wax teeth (Kemdent Anutex Associated dental products).

The maxillary wax teeth were replaced with identical prosthetic teeth using face bow index as a guide for tooth position. Once, the maxillary teeth were correctly positioned, the face-bow stone index was removed from the articulator and replaced with the mandibular final cast. The mandibular autopolymerizing acrylic resin base with wax teeth was located on the mandibular final cast. The mandibular wax teeth were replaced with identical mandibular prosthetic teeth. The duplicate dentures were processed by conventional compression molding technique using soft acrylic resin type (Vertex soft-Dental B.V., Zeist, the Netherlands). The soft acrylic resin material was mixed, flaked, packed and cured according to the manufacture instructions. The vertex soft acrylic were polymerized in a water bath curing tank for 1½ hour at 70°C and for another ½ hour at 100°C, then let to slowly cool down in the open air.

Laboratory remounting was done to refine the occlusion. A pneumatic chisel was used to remove carefully the soft denture without split from the cast. The denture was finished and polished using the vertex finishing-polishing instruments (vertex Dental Academy, Zeist, Netherlands).
Occasionally, each patient was allowed to wear first, his conventional acrylic denture for 6 months during which all the evaluation parameters were measured. Then the denture was removed from patient’s mouth for 2 weeks as a period of rest. Then soft acrylic denture was secondly delivered to the same patient Fig. (4). Monitoring and data collection continued for additional 6 months. Each patient was examined by three prosthodontists. Data were independently and concurrently recorded by them.

**Evaluation methods:**
The clinical evaluation of soft acrylic denture that used to restore a severely resorbed edentulous ridge in comparable with conventional acrylic denture (control type) was performed by both objective (quantitative) and subjective (qualitative) manner. All patients were allowed to familiarized with the measurement procedure and the instruments.

**Objective evaluations:**

* **Chewing efficiency**
Chewing efficiency of the conventional acrylic resin denture (control) was evaluated firstly for 6 months (one week, three and six months) follow-up periods. Then, there was 2 weeks a period of rest. Chewing efficiency of the soft acrylic resin denture was done for another 6 months by the same schedule of follow-up that previously made.

During each follow-up period, standard 1 cm cubes of two different foods (Carrot and cheese) were given to each patient. He was asked to chew each food cube, measurements of efficiency was recorded as number of chewing strokes until the patient swallowed. Then, time (in seconds) elapsed from the first chewing stroke until patient swallowing, was calculated. Each prosthodontist repeated this measurement for each patient at each test session 3 times. Records of the three prosthodontists were collected and values were reported to be statistically analyzed[37-40].

* **Bite force measurements:**
For each patient at each follow-up session, maximum bite force was recorded using occlusal force meter instrument (Model GM, NaGoNo Keiki Seisakusho, Ltd, J. Morita Corporation, 33-18-3 Chomeo-Torumi-cho-Suita City, Osaka 564-8650, Japan) as shown in Fig. (5).

Bite force was measured for both denture types (conventional and soft) at one week, three, and six months follow-up periods. The recorded force during maximal clenching was obtained with one bite force meter placed between pairs of opposing teeth at one

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**Fig. (4): Finished conventional and soft acrylic dentures.**
(a) Maxillary conventional and soft denture. (b) Mandibular conventional and soft denture
side and four, wood tongue depressor at the other side. The meter and depressor were located at the area of premolar/molar where there is more number of occlusal contacts with strong determinant of muscle action and subsequent great bite force.

Each patient was asked to set comfortably in a dental chair with their head on the headrest and the occlusal plane of the maxillary teeth parallel to the floor. The patients were trained to manipulate the base in their mouth in a consistent manner with uniform digital pressure until it occupied a comfortable and accurate position. One minute was then allowed for the denture base to reach a stable equilibrium position. With self-cure acrylic resin, a hook screw with its nut (Digital force Gauge device Model 47544 Extech instrument, coorporation, Taiwan) was secured in the polished mid-palatal surface of each upper denture and mid-lingual surface of each lower denture to detach it from the patient mouth and record the amount of the force required for dislodgment. The pull end of the digital force gauge device was connected to the hook positioned at maxillary and mandibular dentures for each acrylic type and was pulled vertically until denture dislodgement occurred. Fig. (6).

During testing, the patient was seated in upright position. The tip of the dispocap that covered the arm of the meter device was inserted into the patient mouth and he asked to bite on it slowly. When the force has exceeded the set-point, the buzzer was sound. If the force exceeded 70 KgF, the buzzer would be sound continuously and the biting should be stopped immediately. For each patient, the mean of at least 10 record of the right and left sides were collected from each prosthodontist and used in the statistical analysis. Random errors of maximum bite force were assessed by computing Dahlberg\textsuperscript{41} Statistics; this value is calculated from the differences between the two assessments as follows

\[
\text{Error} = \sqrt{\frac{\sum (\text{first measurement} - \text{second measurement})^2}{(2 \times \text{number of couples of repeated measurements})}}
\]

* Retention force measurements

Retention force measurement was made according to the method proposed by Kikuchi et al., 1999\textsuperscript{42}, using force measurement gauge (Digital force gauge device model 47544 Extech instrument, cooperation, Taiwan; measure tension & compression, pull and push).

The device was always automatically calibrated before and after each test session and no error of any kind was noted in the testing system. None of the patients experienced any discomfort from the level of forces required to dislodge the dentures from their seats.

For each patient, by the end of the follow up period (6 months), the force required to dislodge the conventional or soft acrylic dentures from the upper and lower ridges
were recorded 10 times per each and the average value was taken as a record. The same was repeated with three inter-examiner colleagues. Records were measured by Newton. Then, they were gathered and calculated to obtain the mean retentive values for each ridge in both types of acrylic denture to be statistically analyzed.

**Subjective evaluations;**

*Retention and stability scores*

The complete upper and lower dentures were evaluated subjectively after 6 months for denture retention and stability using the scoring system described by Kapur, 1975 Fig. (7).

### Retention and Stability Scoring Systems

| Patient name: | | | |
| Evaluator: | | | |
| Date: | | | |
| Retention score: | | | |
| Stability score: | | | |
| Post conventional denture: | | | |
| Post soft denture: | | | |
| Retention: | | | |
| Retention: conventional D: | | | |
| Retention: Soft D: | | | |

<table>
<thead>
<tr>
<th>Retention Criterion</th>
<th>Stability Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 No retention</td>
<td>0 No stability</td>
</tr>
<tr>
<td>(when a denture is not seated in its place, its displaces itself)</td>
<td>(when a denture base demonstrates extreme rocking on its supporting structure under pressure)</td>
</tr>
<tr>
<td>1 Minimum retention</td>
<td>1 Some stability</td>
</tr>
<tr>
<td>(when a denture offers slight resistance to vertical pull, and little or no resistance to lateral forces)</td>
<td>(when base demonstrates moderate rocking on its supporting structure under pressure)</td>
</tr>
<tr>
<td>2 Moderate retention</td>
<td>2 Sufficient stability</td>
</tr>
<tr>
<td>(when a denture offers resistance to lateral forces)</td>
<td>(when a denture demonstrates slight or no rocking on its supporting structures under pressure)</td>
</tr>
<tr>
<td>3 Good retention</td>
<td></td>
</tr>
<tr>
<td>(when a denture offers maximum resistance to vertical pull and sufficient resistance to lateral forces)</td>
<td></td>
</tr>
</tbody>
</table>

**Fig. (7): Retention and stability data form**
*Tissue condition score:*

The condition of the denture-supporting tissues in both arches were evaluated with the criteria-based scoring system described by Rayson et al., 1971 (44) Fig. (8). The evaluation consisted of four criteria that described the tissue. Clinical observation along with pressure-indicating paste (PIP) patterns were recorded and used in the evaluation. The numbered criteria that best described the patient’s tissue condition were recorded. Higher scores indicated more favorable tissue conditions.

The data obtained from the three prosthodontist were collected at one week and 6 months follow-up for each type of denture to be statistically analyzed.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1. Large general region of redness involving half or more of the denture bearing surface or a considerable amount of movable tissue not present before or both.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Some movable tissue on the crest of ridge not previously present or irritated regions covering one-third of the denture bearing area.</td>
</tr>
<tr>
<td>3.</td>
<td>The tissues are generally firm and appear healthy except for small isolated regions.</td>
</tr>
<tr>
<td>4.</td>
<td>Tissues are firm and appear healthy with no signs of abrasion or other injury caused by the dentures.</td>
</tr>
</tbody>
</table>

All abnormal areas are to be scribed on the drawing and the following coding used:

- **R:** Redness (isolated)
- **H:** Hyperplastic tissue
- **I:** Inflammation (general)
- **U:** Ulceration
- **L:**

Drawing and PIP record

Fig. (8): Tissue condition data form
* Denture complaints score, chewing ability score and overall denture satisfaction rate:

Variables used for treatment outcome assessment primarily focused on the subjective appreciation of the denture. Denture satisfaction was assessed with a validated self-administered questionnaire at 1 week and 6 months for each type of denture\(^{(45,46)}\). Twelve questions addressed problems with functioning with the lower denture and seven questions concerned the upper denture. The extent of each specific complaint could be expressed on a four-point rating scale (0=no, 1=little, 2=moderate, 3=severe complaints). Five questions addressed chewing ability problem of soft and hard food, each with a three-point rating scale (0=good, 1=moderate, 2=bad). The patient’s overall denture satisfaction was expressed on a 10-point rating scale (1=very bad to 10=excellent). On each factor, final scores were calculated as the mean of the item scores, ranging from zero to three for the complaints questionnaire and from zero to two for the subjective chewing ability. All data obtained (objective and subjective) were gathered, tabulated and statistically analyzed.

Data analysis

To determine, significant difference between the soft and conventional acrylic dentures, a two-way analysis of variance with repeated measures on two factors was used to analyze the values of bite force and chewing efficiency. While, the other evaluated parameters as retention force measurements and scores, stability scores, denture complaint scores, chewing ability scores, denture satisfaction rate and tissue condition scores were compared in both type of denture using signed rank test. P-value ≤0.05 were considered statistically significant. While those <0.01 were considered highly significant.

RESULTS

Eleven completely edentulous male patients received twenty-two success full complete dentures. Each patient received one complete denture constructed by conventional heat cured acrylic resin (type I control) and another one constructed by soft heat cure acrylic resin denture (type II). They were followed up clinically to record the chewing efficiency, bite force and retention force values (objective parameters). Additionally, the retention and stability scores, denture complaint and chewing ability problems scores, patient satisfaction rate and tissue condition scores were assessed (subjective parameters).

Chewing efficiency (Masticatory performance):

Six chewing efficiency records were made for each patient as follows: 3 times periods for conventional acrylic denture (one week, 3 months, 6 months) and another 3 times periods for soft acrylic denture (one week, 3 months, and 6 months). The data obtained from the prosthodontist for each type and at each time period were summarized and reported in the form of mean values of both the chewing times and number of chewing strokes. Then the number of chewing velocity (stroke/sec) were calculated to compare between both types of denture when chewing carrot and cheese.

Chewing hard food:

To compare between the chewing efficiency of both types of acrylic denture; the mean values and standard deviations of chewing velocity (number of strokes/unit time) of both type were calculated throughout different follow-up periods and tabulated (Table 1). The mean value of chewing velocity were 1 ± 0.03, 1±0.03, 1.01±0.03 for conventional acrylic denture, while those for soft acrylic denture were 0.93±0.12, 0.99±0.05 and 0.97±0.03 at one week, 3 and 6 months follow-up periods respectively.

There was a significant difference of chewing velocity between both types of acrylic denture infavor to conventional (p<0.03). While; there was no significant difference in both types by time.
During chewing soft food, the mean values of chewing velocity were 0.95±0.09, 0.97±0.09 and 1.05±0.10 for the conventional acrylic denture, while for the soft acrylic denture were 0.96±0.09, 0.96±0.09 and 0.98±0.07 at one week, three and six months follow up period respectively Table (2). No statistical difference between the conventional and soft acrylic dentures when chew a soft food. However, there was a significant increase of chewing velocity by time in each type in favor to conventional acrylic denture.

**TABLE (1)** Analysis of the chewing efficiency in both conventional and soft acrylic complete dentures when chewing hard food at different follow-up periods

<table>
<thead>
<tr>
<th>Time</th>
<th>Conventional acrylic denture</th>
<th>Soft acrylic denture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No of strokes Mean±SD</td>
<td>Time in sec Mean±SD</td>
</tr>
<tr>
<td>1W</td>
<td>26.91±3.51</td>
<td>26.91±3.58</td>
</tr>
<tr>
<td>3M</td>
<td>25.55±3.36</td>
<td>25.57±3.26</td>
</tr>
<tr>
<td>6M</td>
<td>24.55±3.39</td>
<td>24.21±3.46</td>
</tr>
</tbody>
</table>

**ANOVA results**

<table>
<thead>
<tr>
<th>Variable</th>
<th>P-value</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>0.340</td>
<td>NS</td>
</tr>
<tr>
<td>Type</td>
<td>0.030</td>
<td>Sig</td>
</tr>
<tr>
<td>Time/type interaction</td>
<td>0.223</td>
<td>NS</td>
</tr>
</tbody>
</table>

*All values are mean ± standard deviation P-value ≤ 0.05 are considered significant NS: Non significant Sig. Significant*

**Chewing soft food:**

**TABLE (2)** Analysis of the chewing efficiency in both comparison of conventional and soft acrylic complete denture when chewing soft food at different follow-up periods

<table>
<thead>
<tr>
<th>Time</th>
<th>Conventional acrylic denture</th>
<th>Soft acrylic denture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No of strokes Mean±SD</td>
<td>Time in sec Mean±SD</td>
</tr>
<tr>
<td>1W</td>
<td>11.82±2.09</td>
<td>12.34±1.48</td>
</tr>
<tr>
<td>3M</td>
<td>11.09±2.21</td>
<td>11.40±1.7</td>
</tr>
<tr>
<td>6M</td>
<td>10.45±2.25</td>
<td>9.94±1.61</td>
</tr>
</tbody>
</table>

**ANOVA results:**

<table>
<thead>
<tr>
<th>Variable</th>
<th>P-value</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>0.030</td>
<td>Sig</td>
</tr>
<tr>
<td>Type</td>
<td>0.189</td>
<td>NS</td>
</tr>
<tr>
<td>Time/type interaction</td>
<td>0.052</td>
<td>Sig</td>
</tr>
</tbody>
</table>

*All values are mean ± standard deviation P-value ≤ 0.05 are considered significant NS: Non significant Sig. Significant*
**Bite force measurement:**

According to Dahlberg’s equation, the error of the measurement for the maximum bite force was (7.9%) within the acceptable range <10%.

The recorded mean values of biting force for conventional and soft acrylic dentures were 5.45 ± 0.52 and 4.75 ± 1.12 at one week, 8.82 ± 1.02 and 7.81 ± 1.28 after three months and 8.18 ± 1.20 and 7.49 ± 1.29 at six months follow-up periods respectively Table (3).

Analysis of the result revealed a significant difference between the two types of denture (P<0.001), where the conventional acrylic denture showed higher biting force values. There was also a significant increase in the bite force values by time in each type. Change occurred with time was the same in both types.

**TABLE (3) Analysis of the biting force measured (Mean ± SD) in comparison of conventional and soft acrylic complete dentures at different follow-up period**

<table>
<thead>
<tr>
<th>Time</th>
<th>Conventional acrylic denture mean ± SD</th>
<th>Soft acrylic denture mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1W</td>
<td>5.45 ± 0.52</td>
<td>4.75 ± 1.12</td>
</tr>
<tr>
<td>3M</td>
<td>8.82 ± 1.02</td>
<td>7.81 ± 1.28</td>
</tr>
<tr>
<td>6 M</td>
<td>8.18 ± 1.20</td>
<td>7.49 ± 1.29</td>
</tr>
</tbody>
</table>

**ANOVA results:**

<table>
<thead>
<tr>
<th>Variable</th>
<th>P-value</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>&lt;0.001</td>
<td>Sig.</td>
</tr>
<tr>
<td>Type</td>
<td>&lt;0.001</td>
<td>Sig.</td>
</tr>
<tr>
<td>Time/type</td>
<td>&lt;0.111</td>
<td>Sig.</td>
</tr>
</tbody>
</table>

**Retention force measurement**

The objective measures, force gauge-measured retention, were considered the primary measures of efficacy and the subjective measures were considered secondary.

The means (± standard deviations) and P-values from the analyses for the measured retention data are listed in table (4). Conventional acrylic mandibular denture had statistically significantly greater retention values than the soft acrylic ones (P=0.001). However, maxillary soft acrylic denture had a statistically significantly greater retention than the conventional acrylic one (P= 0.044).

**TABLE (4) Analysis of the retention force values in comparison of the conventional and soft acrylic complete dentures at 6 months**

<table>
<thead>
<tr>
<th>Arch</th>
<th>Conventional acrylic denture (mean ± SD)</th>
<th>Soft acrylic denture (mean ± SD)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandible</td>
<td>8.44 ± 1.55</td>
<td>3.93 ± 1.65</td>
<td>0.0010*</td>
</tr>
<tr>
<td>Maxilla</td>
<td>26.53 ± 7.22</td>
<td>28.52 ± 7.45</td>
<td>0.0449*</td>
</tr>
</tbody>
</table>

* All values were means ± standard deviation

* P-value ≤ 0.05 are considered significant

**Retention and stability scores**

The results of the subjective measures which included; the retention and stability scores are seen in table (5).

The data were demonstrated as median (±range). It was clear that the conventional acrylic denture had a statistically significantly greater retention score for the mandibular arch than soft acrylic denture. While, with maxillary denture, no significant difference were recorded for the both types of acrylic.

With respect to stability scores, no statistical difference was observed between the conventional and soft acrylic dentures either in the mandible or the maxilla.
TABLE (5) Analysis of the retention and stability scores in comparison of conventional and soft acrylic complete dentures at 6 months

<table>
<thead>
<tr>
<th>Variables</th>
<th>Arch</th>
<th>Conventional acrylic denture median (range)</th>
<th>Soft acrylic denture median (range)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retention</td>
<td>Mandible</td>
<td>2 (1-3)</td>
<td>1 (0-2)</td>
<td>0.0156'</td>
</tr>
<tr>
<td>Retention</td>
<td>Maxilla</td>
<td>2 (2-3)</td>
<td>3 (2-3)</td>
<td></td>
</tr>
<tr>
<td>Stability</td>
<td>Mandible</td>
<td>2 (1-2)</td>
<td>1 (0-2)</td>
<td>0.0625</td>
</tr>
<tr>
<td>Stability</td>
<td>Maxilla</td>
<td>2 (1-2)</td>
<td>2 (1-2)</td>
<td>0.5000</td>
</tr>
</tbody>
</table>

All values are median (± range) * P-value ≤ 0.05 are considered significant

Tissue condition scores

The tissue score data were represented as median (± range) in Table (6). Values were equal for both the soft and conventional acrylic dentures at each follow-up period. No statistical difference were observed between conventional and soft acrylic dentures either for the mandible or maxilla at different follow-up periods (1 week – 6 months).

Denture complaint scores, chewing ability problem scores and denture satisfaction rate

All collected data were summarized in table (7&8) in the form of median (± range) at one week and 6 months follow-up periods respectively.

TABLE (6) Analysis of the tissue condition scores data in comparison of the conventional and soft acrylic complete dentures at 1 week and 6 months follow-up period.

<table>
<thead>
<tr>
<th>Arch</th>
<th>Time</th>
<th>Conventional acrylic denture</th>
<th>Soft acrylic denture</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandible</td>
<td>1W</td>
<td>3 (2-4)</td>
<td>3 (3-4)</td>
<td>0.5000</td>
</tr>
<tr>
<td></td>
<td>6M</td>
<td>3 (2-4)</td>
<td>3 (2-4)</td>
<td>0.5000</td>
</tr>
<tr>
<td></td>
<td>1W</td>
<td>3 (2-4)</td>
<td>3 (3-4)</td>
<td>0.0625</td>
</tr>
<tr>
<td>Maxilla</td>
<td>6M</td>
<td>3 (2-4)</td>
<td>3 (3-4)</td>
<td>0.5000</td>
</tr>
</tbody>
</table>

All values are Median (± range) * P-value ≤ 0.05 are considered significant

One week evaluation

The patient recorded significantly higher complaint scores for lower denture when wearing the soft acrylic type (P= 0.003). While, for upper denture, the reverse was observed where, the patient recorded high significant complaint score when wearing the conventional acrylic type (P=0.002).

Difference in chewing ability problem scores between conventional and soft acrylic denture when chewing hard and soft food were not statistically significant. The overall denture satisfaction rating were equal in both types of acrylic denture. Table (7)
TABLE (7) One-week post treatment scores (median ± range) of the denture complaint, chewing ability problem and overall denture satisfaction rating questionnaires.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Conventional acrylic denture</th>
<th>Soft acrylic denture</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complaint of lower denture (Score 0-3)</td>
<td>1.4 (0.9-1.7)</td>
<td>1.5 (1.1-1.8)</td>
<td>0.0039*</td>
</tr>
<tr>
<td>Complaint of upper denture (Score 0-3)</td>
<td>1.1 (0.8-1.3)</td>
<td>0.9 (0.7-1.1)</td>
<td>0.0020*</td>
</tr>
<tr>
<td>Problem in chewing soft food (Score 0-2)</td>
<td>1.1 (0.9-1.4)</td>
<td>1.1 (0.9-1.4)</td>
<td>0.7969</td>
</tr>
<tr>
<td>Problem in chewing hard food (Score 0-2)</td>
<td>1.6 (1.1-1.8)</td>
<td>1.7 (1.1-1.8)</td>
<td>0.2500</td>
</tr>
<tr>
<td>Satisfaction rate (Score 1-10)</td>
<td>4.9 (4.1-7.5)</td>
<td>4.8 (3.9-7.2)</td>
<td>0.9941</td>
</tr>
</tbody>
</table>

All values are median (± range) * P ≤ 0.05 are considered significant

Six months evaluation

For lower denture, the patient were still recorded significant complaint score when wearing the soft acrylic type (P=0.002). Also, for upper denture the patient recorded high significant complaint score when wearing the conventional acrylic type (P=0.002). The chewing ability scores were not significantly, different between both types of acrylic denture when chewing soft food. However, a significant difference was observed between both types of acrylic denture when chewing hard food, where (P=0.002).

Soft acrylic type had a higher chewing ability problem than those of the control type. The overall denture satisfaction rate was increased by time in both types of acrylic with the same rate. Table (8).

TABLE (8) Six-months post treatment score (median ± range) of the denture complaint chewing ability problem and overall denture satisfaction rating questionnaires.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Conventional acrylic denture</th>
<th>Soft acrylic denture</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complaint of lower denture (Score 0-3)</td>
<td>1.1 (0.7-1.5)</td>
<td>1.2 (0.9-1.6)</td>
<td>0.0020*</td>
</tr>
<tr>
<td>Complaint of upper denture (Score 0-3)</td>
<td>0.8 (0.6-1.1)</td>
<td>0.6 (0.5-1.1)</td>
<td>0.0020*</td>
</tr>
<tr>
<td>Problem in chewing soft food (Score 0-2)</td>
<td>0.9 (0.6-1.1)</td>
<td>0.9 (0.6-1.2)</td>
<td>0.8594</td>
</tr>
<tr>
<td>Problem in chewing hard food (Score 0-2)</td>
<td>1.1 (0.9-1.6)</td>
<td>1.4 (1.1-1.7)</td>
<td>0.0020*</td>
</tr>
<tr>
<td>Satisfaction rate (Score 1-10)</td>
<td>7.3 (5.1-8.5)</td>
<td>7.6 (4.8-8.6)</td>
<td>0.3438</td>
</tr>
</tbody>
</table>

All values are median (± range) * P ≤ 0.05 are considered significant
Wearing complete denture may have adverse effects on the health of both the oral and the denture supporting tissues. Although the prevalence of an edentulous condition is decreasing, the great number of edentulous people warrants the continuing efforts of basic and clinical research on removable prosthesis. Patients were selected with their age ranging from 45 to 55 (mean age of 50 years) to avoid muscle atrophy due to senility. There is variation in muscle efficiency due to age, as the patients in the same age group show almost the same muscle efficiency\(^\text{47}\). The selected patients were male to avoid the difference in muscle efficiency between different sexes\(^\text{48}\). There are a variety of factors may contribute to preference of male selection\(^\text{49}\), including hormonal alternations\(^\text{50}\), blood pressure\(^\text{51}\) and psychological factors\(^\text{52}\). Furthermore, elderly females showed a lower rate of chewing efficiency than males\(^\text{53}\). Patients with systemic disease or neuromuscular disorders were excluded to avoid any effect on the muscle tone and hence resultant masticatory efficiency\(^\text{54}\). Patients with temporo-mandibular joint dysfunction were also excluded to avoid any disturbance in muscle behavior\(^\text{55}\). Moreover; patients with abnormal ridge relationship were avoided because dentate subjects with normal occlusion were found to have a better masticatory efficiency than subjects with malocclusions\(^\text{56}\). The abnormal tongue behavior or size and/or xerostomia or excessive salivation were exclusive factors during the patients selection, as that may affect the dentures stability, retention and subsequent the patient’s satisfaction rating\(^\text{57}\).

Incorporation of accurate centric relation was important not only for mounting lower cast but also to avoid jeopardization of retention, stability and interference with mastication\(^\text{51,58}\). Ideally, to establish bilateral balanced occlusal scheme, fully adjustable articulator should be used. However; it is not always available. Hanau model (H) semi-adjustable articulator was used and therefore the only eccentric record made was protrusive one. While lateral condylar guidance (L), was adjusted according to the equation: \(L = H/8 + 12\). Laboratory remounting was done to overcome errors that might happen during processing\(^\text{50}\). Also, clinical remounting was done to allow adjustment of occlusion. The oral cavity limits the visibility to accurate positioning and examination of teeth. In addition the resiliency of oral tissues precludes constant equalization of pressure. In various denture positions, the denture bases shift under incline plane stress without the operator being aware of it, whereas on a stone cast this can not happen\(^\text{52}\). Finished dentures were tried in the patient’s mouth at the time of delivery to check for any occlusal discrepancies and border extensions that could impair denture stability as well as retention that might affect masticatory efficiency during the initial learning period after denture insertion. Then the dentures were kept in the patient’s mouth for 48 hours to allow for interceptive settling and initial acclimation\(^\text{59}\). The same patients received both types of denture alternatively to avoid bias resulting from individual variation\(^\text{54,60,61}\).

The objective evaluation of masticatory efficiency was made during chewing different types of food, either hard or soft (carrot and cheese)\(^\text{62,63}\). Carrot and cheese were chosen as test food material, because of their reliable natural test and their suitability for complete denture wearers who could easily crush and comminute them\(^\text{64}\). Moreover, both carrot and cheese were cut into small and symmetrical pieces of about 1 cm to eliminate the influence of different food size on muscular efficiency\(^\text{64,65}\). Gunne et al., 1982\(^\text{66}\), demonstrated that complete denture wearers often use more than 30 strokes before they feel ready to swallow. The number of strokes was counted until swallowing to allow expression of the reproducibility of the method and the biological intra-individual variation; therefore providing small difference for every patient between repeated record. Many authors\(^\text{37,38,47}\) overcome the individual variation regarding counted number of strokes until swallowing, through correlating the masticatory performance percentage obtained by sieving method to both number of strokes and time of chewing until swallowing. They concluded that the number of chews as well as time of chewing taken before
swallowing increase as the chewing efficiency decreases. Additionally, Gunne, 1985 had mentioned that the chewing efficiency could be calculated by velocity of chewing, i.e. number of strokes/second. It is worthy to mention that, the greater number of masticatory strokes and longer time were observed were during chewing carrot than that showed during chewing cheese in both types of acrylic denture evaluated in this study. This could be contributed to the hard fibrous nature of carrot necessitating much greater amount of force to grind it than that required for chewing cheese. This was in line with Horio and Kawamura, 1989, who reported that the fibrous and granulous nature of food seem to be more critical for determining chewing rate than hardness. Also, Karkazis and Kossino, 1998, showed that in complete denture wearers, the masseter muscle activity was higher for chewing carrots than chewing apple. Additionally, it should be emphasized that the comparison between the two acrylic dentures regarding either number of chewing strokes or time of chewing could be easily made and be more pronounced on level of hard food. The physical and chemical characteristics of the food itself directly influence jaw and muscle performance. Also, Horio and Kawamita, 1989, reported that in the majority of subjects, chewing forces and chewing movements were influenced by the texture of food; as it is well known that the neuromuscular modulation plays a major role on denture retention, and stability which is directly reflected on masticatory ability in removable prosthesis.

Vegrune et al., 2007 have reported that complete denture wearers were able to adapt their mastication to hardness of food substance by increasing the number of strokes and duration of masticatory sequence. A finding that goes in accordance with the result of the present study. Moreover, Allen et al., 2001, mentioned that the problems related to the edentulous patient will continue to challenge the dentists particularly as the ability to adapt to conventional complete denture even having excellent prosthetic criteria. Hence, patients opinion can not be ignored, although it is a subjective result, but at the same time can not be considered as a final result in view of the objective result. The masticatory function is difficult to examine objectively only because it is subjected to individual variations. There are several controversies for how to evaluate the masticatory efficiency. It was recommended to use more than one interrelated methods for accuracy of evaluation.

The objective in any prosthetic restoration is not only to have a good masticatory function, but also to maintain the health of remaining structures among which is the residual alveolar ridge. There is a good relationship between the occlusion and the neuro functional behavior of the masticatory muscles. Masticatory performance and ability were partly dependent on the occlusion. Additionally, Yamashita et al., 1999, have confirmed that the masticatory performance is based upon occlusal scheme, chewing pattern and force; as the ideal performance is dependant upon matching the chewing pattern to the occlusal scheme.

Pietrokovski et al., 1995 reported that the lower complain scores given for maxillary denture can be attributed to the fact that most maxillary denture are easier to make and more comfortable to wear than mandibular dentures. In the present study maxillary conventional acrylic denture showed relatively higher complaint scores. This contradiction may be explained on the basis that palatal mucosa may rubbed between the maxillary bone and denture as the result of denture movement over severely resorbed ridge. Additionally, the complaint scores were higher with the mandibular denture processed with soft acrylic. This finding was in agreement with Fenlon et al. 2007. The vast majority of the denture complaints concerns the lower denture. This is related to the more severe resorption of alveolar bone in the mandible than in the maxilla. The reduced denture-bearing area, denture quality, dentist-patient interaction, previous denture experiences and the patient’s psychological well being personality are all determinants of the patient’s satisfaction with his dentures. The favourable short-term results of maxillary soft acrylic denture could be attributed to the effect of the enlargement of the dental bearing area for denture support and clarification the effect of physical means of retention.
The retention and stability data were collected at 6 month only for analysis for two reasons. First, the mean and median did not change much from 1 week, three month to six months. Therefore, there was no reason to analyze the other two time periods. Second, even if the means had changed overtime, the 6 months data as a measure of long-term efficacy, were more appropriate. It has been suggested that gravity and the addition of weight to the mandibular complete denture may aid in prosthesis retention. Variations in palatal dimensions and structure such as surface area length, depth, angulations of the palate and presence of undercut can also influence the ultimate retention of maxillary denture. The limit of effectiveness of the salivary film in retaining the denture base might depend on the nature of its adhesion to the fitting surface of the denture base. It was hypothesized that an altered fitting surface of soft acrylic denture may give better results than a conventional fitting surface of the denture base made after routine processing procedures. There was increase in the surface area of the denture base and improved the adhesion of saliva to the surface. This could support the results of this study as conventional acrylic type had a higher retentive value for the mandibular denture than the soft acrylic type. The lower denture retention depend on the mechanical means which include the engagement of undercut at the lingual pouch. In contrast, maxillary denture processed from soft acrylic type showed a higher retentive value than the conventional acrylic type. Recent studies indicated that improvements in retention and stability result in no improvement in masticatory function or ability in conventional denture patients treated with new conventional or implant-retained overdentures. This findings were observed in this study.

Idowa et al., 1987 mentioned that the objective masticatory performance has been predicted by denture stability but not by occlusal form of artificial teeth in elderly denture wearers. This explained why there was no difference between the conventional and soft acrylic dentures regarding the chewing ability scores and stability scores. The better stability of the denture, the patient with less muscular effort. Shinkai et al., 2002 suggested that people with good quality denture (good retention and stability) are not necessarily more likely to have better diets than people with poorly fitting or worn dentures.

Bite force is reduced with risk for atrophy of the masticatory muscles especially, in the elderly complete denture wearer. Furthermore, the bite force decreases with further opening in corresponding to the optimum length of the jaw-elevator muscle. This so called length-tension relationship should be considered when assessing maximum bite force with a bite force meter that increases bite height and jaw separation. This explain why the bite force measurement were done on both side of the same patient mouth. The number of occlusal contacts is a strong determinant of muscle action and bite force than the number of teeth. This support the insertion of the bite force meter posteriorly at the premolar-molar area of the tested dentures. With respect to chewing pattern, patients were instructed to chew on one side and then on the other. The one side chewing produced a lever action with the ridge on the chewing side that becomes the fulcrum and causes vertical movement of the denture base on the contralateral side. This may contributed to trauma to the tissue of the supporting structure. This support the insertion of the bite force meter on one side and tongue depressor on the other side to obtain a more symmetrical muscle contraction.

Patient satisfaction is important for a treatment to be regarded successful. The real value of any treatment can only be evaluated when it is compared to the outcome of a standard treatment (control type) as conventional denture in this study. Patients satisfaction with their dentures were higher at 6 months after denture insertion than that at 1 week post insertion. This adaptation may be due to the neuromuscular control which is gradually and slowly generated by time, i.e. the longer the period of denture wearing, the better the neuromuscular control gained.
CONCLUSIONS

Based on the results of this current study:

The following can be concluded:

- Chewing efficiency showed marked increased by time in favor to the conventional acrylic denture. The higher value of efficiency obtained with chewing hard food.
- The chewing ability problems scores were observed significantly after 6 month with soft acrylic denture.
- The bite force values increased by time in both types of acrylic denture. The conventional acrylic denture had a higher biting force value than the soft acrylic ones.
- Mandibular conventional acrylic denture had a higher retentive value. In contrast, the maxillary denture had a higher retentive value when processed by soft acrylic material. Furthermore, the retention scores confirmed this result.
- Stability scores were approximately recorded same value for both types of acrylic denture.
- Denture complaint scores were higher with both mandibular soft and maxillary conventional acrylic dentures.
- Tissue responses were nearly the same in both types of acrylic denture.
- The patients were satisfied with both types of acrylic denture in favor to conventional type.

RECOMMENDATIONS

With respect to the previous observations and findings, a favorable treatment modality for severely resorbed ridges in completely edentulous patient, a combination of both types of acrylic resin is recommended. The mandible can receive denture processed from the conventional acrylic resin to engage mechanically the lingual undercut and to give a good retention, stability and function of the prosthesis. On the other hand, the maxilla can receive complete denture processed from the soft acrylic resin to gain more physical adhesion and cohesion of the saliva to a broader supporting area that achieve a high retentive value, stability and function of the prosthesis.

REFERENCES


Shi CS, Gman QY and Guo TW. Masticatory efficiency determined with direct measurement of food particles masticated by subjects with natural dentition. J Prosthet Dent; 1990, 64:723


