Original Article

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Dentistry Section

Retention of Maxillary Denture Bases Fabricated Using Three Different Border Moulding and Final Impression Materials: A Comparative Experimental Study

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ABSTRACT

Introduction: Denture dislodgement is prevented by retention and stability which in turn depends on the optimum extension of a denture base. Development of border seal is of utmost importance to maintain the contact between the denture and the adjacent vestibular tissue, achieved by border moulding. Establishing a correlation between the final impression and border moulding materials and the improvement of denture base retention will help to ameliorate post insertion patient satisfaction. The rationale of this study was to identify the best materials for border moulding and final impression to improve denture retention, stability, and fit.

Aim: To compare maxillary complete denture retention with three different types of materials used for border moulding and final impression.

Materials and Methods: The present comparative experimental study was conducted in the Department of Prosthodontics and Crown and Bridge, GNIDSR, Kolkata, West Bengal, India, involving 10 completely edentulous patients of either from November 2017 till July 2019, making use of three different border moulding and impression techniques to fabricate maxillary denture bases, whose retention was measured using a digital force gauge. Subjects were analysed for retention in three different groups: Group A (Green stick + Zinc Oxide Eugenol (ZOE), Group B (Addition silicone putty + light body), Group C (Polyether). Statistical analysis for the study was done using version 24.0 of Statistical Package for Social Sciences (SPSS) and 5th version of GraphPad Prism Statistical analysis was done using Analysis of Variance (ANOVA) and student's t-test and significance was set at $p<0.05$.

Results: Ten edentulous patients (mean age range of 50-70 years, 60% females and 40% males) were analysed for retention. Demographic parameters considered were age, gender and oral health status of the patient. ANOVA and student t-test was used for statistical analysis ($p<0.05$ was considered significant). Group A and B showed similar retention and both showed significant higher retention than Group C. Mean retention values were highest in Group A (4599.4000), followed by Group B (3605.5000) and Group C (2526.9000), respectively.

Conclusion: Green stick border moulding proved to be more retentive followed by addition silicone putty with polyether exhibiting the least retention. Sectional moulding is more retentive than single step emphasising the importance of incremental adaptation. The findings confirm that border moulding technique and material selection is highly impactful on patient satisfaction and denture retention.

Keywords: Green stick, Heat cure denture base, Polyether, Single stage border moulding

INTRODUCTION

According to the befitting words of DeVan "our task is not to try to maintain function in scope degree and direction as it had been prior to the mutilation, but rather to preserve what remains of the oral mechanism" [1]. Determination of denture base extension aids in providing better support, retention and stability [2]. One of the elemental prerequisite for the final success of a conventional denture depends on the internal adaptation of resin base to the residual alveolar ridge, which in turn depends on the precision of final impression. Many materials and varied techniques of prosthesis fabrication have been proposed to provide better adaptation and retention [3]. Mucostatic impression technique, originally formulated by Page HL, focused on the physical factors of retention in impression making [4]. Later, Addison PI stated that this method might result in unstable dentures or stable dentures that force the tissue into more or less rapid degeneration [5]. Applegate ruled out the mucostatics, naming it as impractical. Finally, the modified basal seat loading impression technique was introduced with an attempt to articulate the best features of both mucostatic and mucocompressive techniques, and is being used till date. A secondary impression plays an important role in the success of final denture prosthesis, and should be made without distortion of basal seat and peripheral tissues, however modelling compound preliminary impression produces tissue displacement and can result in irritation and dislodgement if duplicated in finished denture, there in raises the need for a definitive impression to achieve the proper peripheral seal [6]. Retention and stability are the two basic factors that prevent denture dislodgement and enhance the chewing efficiency [7]. Glossary of prosthodontic terms-9 has defined denture retention as the "resistance in the movement of a denture away from its tissue foundation especially in a vertical direction and it is a quality of a denture that holds it to the tissue foundation and/or abutment teeth and stability as the resistance to horizontal and rotational forces. This property prevents lateral or anteroposterior shunting of the denture base [8]. The conventional complete denture fabrication is an indirect prosthetic process that needs an analogue of oral conditions which should be an accurate representation of the anatomic and mechanical conditions of the oral cavity and it can only be achieved with a proper development of border seal, which in turn maintains the denture border and adjacent vestibular tissue contact, both in rest and function and this can only be achieved by border moulding [9]. The procedure of border moulding and final

impression to closely attune it to the vestibular tissues is a time-honoured procedure and the original material used for such is modeling compound presented by Green brothers in 1907. The low fusing impression compound while making final impression, uses a technique that involves multiple steps, where borders are moulded in separate sections that require minimum 24 tray insertions, eight times for upper and sixteen for lower, making it more tedious, hence materials allowing simultaneous moulding of borders to reduce the number of tray insertions, came to the forefront [10].

The present study aimed to make a comparative evaluation of denture base retention, fabricated on master casts derived from three different ways of border moulding of special trays and final impression with three different materials to determine their impact on denture retention unlike prior studies emphasising only on individual materials. Additionally, the present study also evaluated the difference between sectional and single step border moulding, enhancing the clinical relevance. Consensus on the best available material for border moulding has not been clearly discussed in any previous studies unlike the present study which aims to bridge that knowledge gap, improving the overall satisfaction and patient quality of life. This study aimed to assist the Prosthodontists in selecting the proper material for border moulding and final impression. The study was based on a null hypothesis that no improvement in retention exists between the denture bases constructed using the mentioned materials.

MATERIALS AND METHODS

The present comparative experimental study was performed from November 2017 to July 2019, in the Department of Prosthodontics and Crown & Bridge, GNIDSR after taking the Institutional Ethical Clearance, (GNIDSR\IEC\18-7) Kolkata,West Bengal, India.

Inclusion and Exclusion criteria: Complete edentulous patients within the mean age range of 50-70 years, willing to participate in the study were included Previously denture wearing patients with less than adequate interarch space. Patients having less than average ridge height, patients with auditory defects, poor neuromuscular control, presence of tori, flabby tissue and severe undercuts were excluded. After explaining study purpose, informed consent was collected from each subject.

Sample size calculation: The sample size was determined using statistical power analysis, considering a 95% confidence level (Z=1.96), p=0.5 (maximum variability) and a margin of error d= 0.31 (i.e., d^2=0.096) estimated effect size, and 80% power. Then this formula $n= Z^2 \times p(1-p)/d^2$ was applied, ensuring adequate representation while maintaining feasibility. It yielded a minimum required sample size of approximately 10 [11].

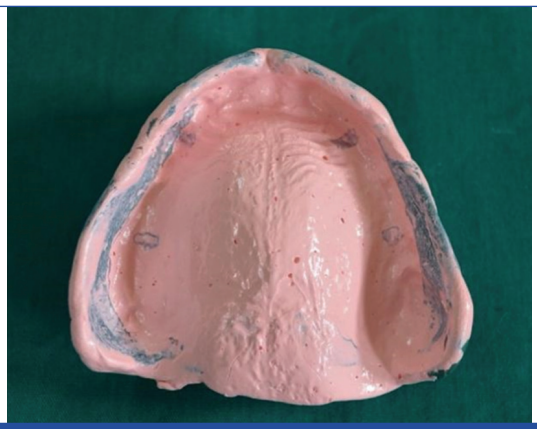
Study Procedure

History taking and detailed clinical examination was done, and primary impressions of both the edentulous arches were made using impression compound. Four tissue stops, of dimension 4 mm×4 mm were drawn in the canine and first molar regions of the primary cast [12]. Subsequently, a two layer modelling wax (3 mm in thickness) was adapted over it simulating the final custom tray, after application of separating medium. It was followed by removal of the wax custom tray from the spacer and subsequent flasking and dewaxing in conventional manner. The flask was packed with heat cured acrylic resin and thermal curing was done and three trays were retrieved and adjusted. Subjects were analysed for retention in three different groups: Group A (Green stick + ZOE), Group B (Addition silicone putty + light body), Group C (Polyether).

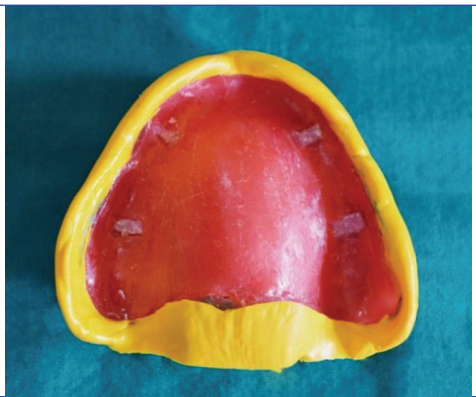
For the first tray (Group A), border moulding was done using low fusing impression compound (DPI Pinnacle tracing stick, India) [Table/Fig-1] followed by zinc oxide eugenol final impression (zinc oxide eugenol impression paste, Type 2 soft, Coltene Whaledent, Mumbai) as seen in [Table/Fig-2]. Secondly (Group B), border moulding using addition silicone putty (Zhermack, Germany) followed by addition silicone light body final impression (Zhermack, Germany) after painting the tray with universal tray adhesive (Zhermack, Germany) as in [Table/Fig-3,4]. For disinfection, the impressions were immersed in 2% glutaraldehyde for 10 minutes. Finally, in the third tray (Group C), both border moulding and impression was made simultaneously using polyether impression material.

(Impregum, 3M ESPE, Germany) as in [Table/Fig-5]. For disinfection of the third tray 0.5% hypochlorite solution was used for 10 minutes [9,10]. Once all the final impressions were made, they were boxed and poured with type III gypsum product (dental stone) to avoid distortion and dimensional changes. Casts were obtained, properly labelled and further proceeded for fabrication of denture bases. A post dam was marked on each casts in a depth and width of 1mm using a no.4 round bur [13]. The cast obtained from the green stick and zinc oxide eugenol impression, was duplicated and the conventional method of complete denture fabrication was carried out with that model, following which the denture was delivered to the patient.

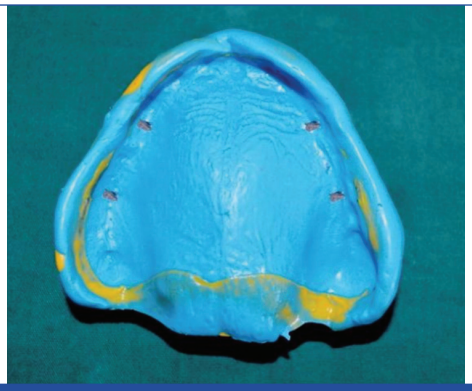
[Table/Fig-1]: Custom tray border moulded using green stick compound following sequential method of material addition.



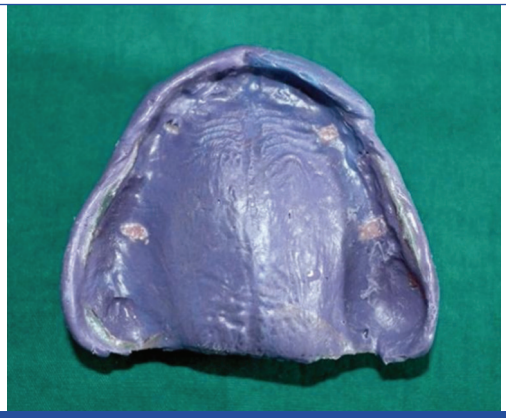
[Table/Fig-2]: Custom tray with Zinc oxide Eugenol washes impression after green stick border moulding.



[Table/Fig-3]: Custom tray border moulded using PVS (addition silicone, putty consistency) using simultaneous method of material addition.

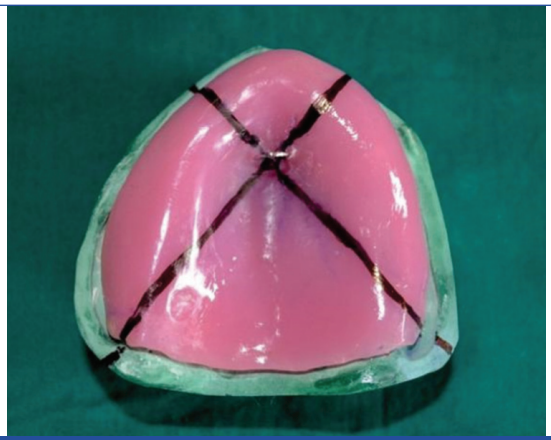


[Table/Fig-4]: Light body (PVS) impression followed after putty border moulding.



[Table/Fig-5]: Single stage border moulding and impression using Polyether impression material.

The final denture bases were finished and polished. An intersection of lines joining canine eminence and hamular notch was marked and a 19 gauge stainless steel loop was fixed at that particular point, using auto polymerised acrylic resin [Table/Fig-6] [13], to engage the hook attached to the nylon fishing line of the apparatus, used to record the retention values. For recording the retentive values, the patient's head was then stabilised using a cephalostat (carestream dental) [Table/Fig-7] and the denture base was seated over the edentulous foundation, intraorally and was held in position for two minutes. The device was then used to apply dislodging force to the denture by using a nylon fishing line that passed through the wire loop attached to the denture [Table/Fig-8] in a clockwise direction and was continued until the time when the denture base finally got dislodged from the foundation. The reading in the



[Table/Fig-6]: Hooks attached at the centre of intersections of lines joining canine eminence and hamular notch.

compact force gauge transducer (Digital hanging weight measuring scale, Weiheng, China) was recorded as the value of the retention. This process was repeated thrice for each of the denture bases. Retention measurements for all the subjects were recorded and the mean of the three measured values in each case were tabulated.

[Table/Fig-7]: Patient's head fixed in a cephalostat and the nylon finishing line attached to the loop in the denture base.

[Table/Fig-8]: T shaped device used for measuring retention.

STATISTICAL ANALYSIS

The data was statistically analysed using SPSS 24.0 software and GraphPad Prism of version 5 significance level was set at $p< 0.05$. Inter group comparisons were done using ANOVA (One-way Analysis of Variance) and for pair-wise comparisons post-hoc Tukey's test was used. Student's t-test was used for intragroup comparisons.

RESULTS

ANOVA test results displaying the mean retentive values for A, B and C which were found to be statistically significant (p-value 0.0049) [Table/Fig-9]. The mean retentive values of the Group A denture bases were on the very higher side followed by the Group B and subsequently Group C.

The Tukey HSD test results indicate statistically significant differences between all group pairs. Group A differs from Group B with a mean difference of 268.8 (95% CI: 37.4–500.3, p=0.0394), from Group C with a mean difference of 611.5 (95% CI: 357.1-866.0, p<0.0001), and Group B differs from Group C with a mean difference of 342.7 (95% CI: 110.7-574.7, p=0.0055). These findings suggest that all groups have distinct mean values, indicating that the treatments or conditions applied to each group lead to significantly different outcomes [Table/Fig-10].

Data has been summarised as mean and standard deviation for numerical variables and percentages for categorical variables. One-way analysis of variance and student t-test was used to

Retention test	Number	Mean	SD	Minimum	Maximum	Median	p-value	F-value
Group A	10	4599.4000	1546.0452	2070.0000	6414.0000	4512.0000	0.0049	6.52
Group B	10	3605.5000	1211.7745	1670.0000	5223.0000	3731.5000		
Group C	10	2526.9000	1043.2993	1093.0000	3991.0000	2370.5000		

[Table/Fig-9]: Distribution of mean retention among three groups.
Test applied: One-way ANOVA for comparison among three groups. F value = 6.52
p-value interpretation: A value of p<0.05 was considered statistically significant difference
SD: Standard deviation; ZOE: Zinc oxide eugenol

Group comparison	Mean difference	95% CI (Lower, Upper)	p-value
Group A vs Group B	268.8	37.4, 500.3	0.0394
Group A vs Group C	611.5	357.1, 866.0	0.0001
Group B vs Group C	342.7	110.7, 574.7	0.0055

[Table/Fig-10]: Post-hoc Tukey's test results between the three groups A, B and C.
Post-hoc comparisons were conducted using Tukey's Honest Significant Difference (HSD) test following a significant One-way ANOVA.

compare means for numerical data, with the level of significance at p=0.05. If the calculated p-value was found insignificant, then the null hypothesis was rejected in favour of the alternative hypothesis. The retentive values for Group A (Green stick border moulding followed by ZOE final impression), Group B (addition silicone putty border moulding followed by light body final impression) and Group C (Using polyether impression material) were determined for all study subjects. The level of significance was found to be insignificant between A and B and significantly related between A and C; B and C and between all the three groups (p-value <0.05). [Table/Fig-11] shows the mean retentive values for A and B which were found to be statistically insignificant (p-value=0.1270).

In [Table/Fig-12] the mean retentive values for A and C are shown, which were also found to be statistically significant (p-value=0.0025) suggesting that border moulding and final impression using green stick and zinc oxide eugenol paste, to be more retentive than with polyether. [Table/Fig-13] showing the mean retentive values for B and C were found to be statistically significant (p-value=0.0469) concluding that border moulding with putty consistency of addition silicone followed by light body final impression to be more retentive than with polyether.

DISCUSSION

Any final treatment outcome depends on the prosthesis acceptance and the incorporation of the same with the patient's oral functions. The success of a complete denture depends on certain factors that requires proper recognition and understanding which in turn improves the denture retention, support and stability by influencing the relationship between the denture surface and the tissue [14]. "Denture retention will be a subject perplexing and perpetual until its troubles find their logical solution in understanding its physics" [15], and is "considered one of the most difficult problems confronting the prosthodontist" [16]. Kaur S et al., compared the maxillary denture base retention with and without border moulding in their study and had shown a 53.18% increase in the retentive forces in the border moulded one. In the present study, primary impression was made for each subject using impression compound, from which casts were obtained and heat cured acrylic resin special tray was fabricated, which was used for three consecutive border moulding and final impression with three different materials [17]. The reason for selection of heat cure resin instead of self-cure was that the heat cure polymethylmethacrylate resins have greater transverse strength, durability, stability and decreased failure on fatigue as stated by Peyton FA et al., [18].

After the tray fabrication, border moulding and final impression was carried out using green stick compound and zinc oxide eugenol, putty consistency of addition silicone with a light body impression wash and single step polyether impression of medium consistency. Green stick has been used widely because it's not only easy to manipulate but also cost effective but it needs multiple insertions so in this study two elastomeric impression materials were used because of its adequate working time, excellent manipulative consistency,

Retention test	Number	Mean	SD	Minimum	Maximum	Median	p-value
Group A (Green stick + ZOE)	10	4599.4000	1546.0452	2070.0000	6414.0000	4512.0000	0.1270
Group B (Addition Silicone putty + Light Body)	10	3605.5000	1211.7745	1670.0000	5223.0000	3731.5000	

[Table/Fig-11]: Distribution of mean RETENTION between Group A and Group B.
Test applied: Student's t-test for inter group comparison. (t=1.60)
p-value interpretation: A value of p <0.05 was considered statistically significant.
SD: Standard deviation; ZOE: Zinc oxide eugenol

Retention test	Number	Mean	SD	Minimum	Maximum	Median	p-value
Group A (Green stick + ZOE)	10	4599.4000	1546.0452	2070.0000	6414.0000	4512.0000	0.0025
Group C (polyether)	10	2526.9000	1043.2993	1093.0000	3991.0000	2370.5000	

[Table/Fig-12]: Distribution of mean RETENTION between Group A and Group C.
Test applied: Student's t-test for inter group comparison. (t=3.51)
p-value interpretation: A value of p <0.05 was considered statistically significant.
SD: Standard deviation, ZOE: Zinc oxide eugenol

Retention test	Number	Mean	SD	Minimum	Maximum	Median	p-value
Group B (Addition Silicone putty + Light Body)	10	3605.5000	1211.7745	1670.0000	5223.0000	3731.5000	0.0469
Group C (Polyether)	10	2526.9000	1043.2993	1093.0000	3991.0000	2370.5000	

[Table/Fig-13]: Distribution of mean RETENTION between Group B and Group C.
Test applied: Student's t-test for inter group comparison. (t=2.13)
p-value interpretation: A value of p<0.05 was considered statistically significant.
SD: Standard deviation

dimensional stability and ease of mouldability with finger pressure in accordance with the study by Yarapatineni R et al., (2013) and Pachar RB et al., (2018) [19,20]. Hooks were attached at the centre of intersections of lines joining canine eminence and hamular notch, of each of the denture bases which is similar to the technique used by Skinner EW et al., (1953) and by Colon A et al., (1982) where the authors advocated the placement of attachment in the middle point as "it had shown more variability of the forces needed to dislodge the denture bases and termed it as the most reliable region for testing the denture retention" [21,22]. The patient's head was then fixed firmly in a cephalostat as was done by Yarapatineni R et al., (2013) and Shekhar A et al., (2018) in their study, to make the Frankfort Horizontal Plane parallel to the floor [19,23]. A device based on an apparatus originally designed by Skinner EW et al., (1953) is used in the study to apply retentive forces [21]. As seen in [Table/Fig-11] the mean retentive values of A and B were 4599.4000 grams and 3605.5000 grams, respectively. The p-value in this case was 0.1270 making it insignificant statistically, which is in accordance with a study by Yarapatineni R et al., (2013) [18], where they found a p-value of 0.1239 on similar comparison. From the [Table/Fig-12,13] of the present study, the value of C was found to be much less (2526.9000 grams) as compared B (3605.5000 grams) and A (4599.4000 grams). The result obtained were contrary to the same study by Pachar RB et al., (2018) where the polyether material was found to be the most retentive (6.72 kgf) when compared with green stick compound (4.59 kgf) and putty elastomeric impression material (4.7kgf) [20]. The reason of such readings may be attributed to some disadvantages associated with the polyether elastomeric impression materials as their elastic recovery is less as compared to polyvinyl siloxane materials, so there might have been some sort of distortion when the polyether impression was retrieved from the patient's mouth.

When comparing the flexibility of the PVS with the polyethers, it was seen that the PVS exhibited a greater flexibility and it could easily flow into the depths of the sulcus areas to record the fine details, but the polyethers had the least flexibility and might had resulted into an inaccurate recording of details. In addition to all these, the polyethers provide a very short setting time, so the completion of border moulding and final impression all in a single step might have been incomplete [24]. So it can easily justify that "polyethers show a slight more viscosity increase as compared to the silicones, thus reducing its flow with time, hence the capability of recording fine details diminishes" [25].

In [Table/Fig-11], the mean distribution of retentive values among the three groups is shown, of which Group A was found to have the highest retentive value statistically which is in accordance to the result obtained by Qanungo A et al., (2016) in their study to compare between single step polyvinylsiloxane border moulding and green stick border moulding sectionally, where the mean retentive force required for denture dislodgement were 8.2650 kgf for PVS and 9.0560 kgf for green stick. They concluded that, putty elastomeric impression material resulted in thick and overextended borders. The manipulation time of the elastomers was also very less, hence proper placement of the material onto the tray and shaping it into a rope could not be done adequately [26]. Greater width of vestibular sulcus by using putty consistency polyvinylsiloxane material is also confirmed from a study by Pridana S et al., (2019), and the reason they cited for such a finding was the high viscosity of this material [27]. The mean retentive values using green stick followed by zinc oxide eugenol in the study (4599.4000 grams) were comparable to the values obtained by Pachar RB et al., (2018) which was around 4.59 kgf [20]. Thus, taking into consideration, all the above mentioned points, green stick border moulding followed by final impression using zinc oxide eugenol is considered to be the most advantageous technique. This material provides an ease of manipulation availability and cost-effectiveness.

More importantly with the use of this material, the custom tray can be inserted multiple times into the patient's mouth and the areas requiring adjustment can be corrected accordingly. Another reason of better performance of sectional border moulding as compared to single step border moulding can be attributed to a study by Yarapatineni R et al., (2013). The reason he cited for such a result was that, uniform scraping along the entire periphery of the border moulded low fusing compound allowed adequate space for the final impression material. Since, the posterior palatal seal could be recorded separately, so it aided in adequate denture retention. Moreover, the zinc oxide eugenol impression paste provides a sufficient flow time for proper placement of borders and is sufficiently resistant to maintain a good contact with the tissues as stated by Klein IE and Broner S (1985) in their study [6,19].

Limitation(s)

The study has several limitations including single centre study design, limiting the application to a wider mass and variability of techniques in border moulding and impression making might have influenced the result. Saliva flow could have interfered with denture retention, which was not controlled in the study. Morphology of the ridge and soft tissue resiliency was not standardised. Denture base adaptation over time was not analysed which could have affected the denture retention.

CONCLUSION(S)

The present study evaluated various border moulding techniques and materials for denture retention. Green stick compound with zinc oxide eugenol yielded the highest retention, while medium viscosity polyether provided the least. Sectional moulding techniques offered superior retention compared to single-stage moulding. No significant difference was found between green stick compound and putty consistency addition silicone in terms of retention. The findings confirm that border moulding technique and material selection is highly impactful on patient satisfaction and denture retention.

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