Original Article

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Comparative Evaluation of Denture Retention using Three Border Moulding Techniques: A Non Randomised Clinical Study

Dentistry Section

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ABSTRACT

Introduction: In complete dentures, the final impression plays a pivotal role in the success of the treatment. Advancements in impression materials have been the primary influence on the evolution of complete denture impression procedures.

Aim: To compare and evaluate the retention of complete dentures fabricated on resorbed ridges using three different border moulding techniques.

Materials and Methods: This non randomised clinical study was conducted in the Department of Prosthodontics and Crown and Bridge at KVG Dental College and Hospital, Sullia, Karnataka, India. The study included 10 patients with resorbed ridges who sought treatment from the Department of Prosthodontics during the period from January 2022 to December 2023. The study participants were selected from Dakshina Kannada and Kasargod, aged between 40 to 70 years, and included both males and females. For each patient, three custom trays were fabricated. The first tray was used for border moulding with putty and light body impression paste recorded using a Transcutaneous Electrical Stimulation (TENS) machine (Group A). The second tray was used for border moulding with putty and light body impression paste (Group B), while the third tray utilised a tissue conditioner as the secondary impression material (Group C). Retention was checked using a force gauge after the secondary impression, and heat-cured dentures were fabricated for each patient. The retention values were statistically analysed using Analysis of Variance (ANOVA), with the significance level set at $p \leq 0.05$.

Results: The measurements indicated significantly higher mean retentive values in Group-A (2.58±0.56 kgf and 2.49±0.99 kgf for the secondary impression and final denture, respectively) compared to the other two groups ($p<0.001$). Comfort was reported to be better in Group-B. Both Groups A and B exhibited a good fit for the dentures.

Conclusion: Within the limitations of the study, it can be inferred that border moulding with TENS using polyvinyl siloxane putty and light body secondary impressions provided higher retention compared to functional border moulding using tissue conditioner.

Keywords: Digital force gauge, Secondary impression, Transcutaneous electrical stimulation, Tissue conditioner

INTRODUCTION

An accurate impression is the foundation of complete denture prosthodontics [1]. A good impression ensures satisfactory retention, stability, and comfort for the patient [1]. Border moulding is the process of shaping the border of the tray to precisely conform to the contours of the labial and buccal vestibule [2]. Various methods of border moulding are described in the literature.

Residual ridge resorption refers to the wearing away of the alveolar ridge following teeth extractions, which complicates the border moulding procedure [3]. Long-span edentulism and the use of ill-fitting dentures can lead to severe resorption of edentulous ridges [3]. Extreme resorption of the ridge, whether in the maxilla or mandible, results in a reduced denture-bearing area that affects retention, stability, and support for the complete denture [4]. Consequently, there is a need to select an appropriate border moulding technique to ensure adequate retention of dentures in resorbed ridges.

In 1971, Jankelson B et al., advocated for recording border moulding using TENS as a possible alternative to conventional border moulding techniques [5]. The conventional method of border moulding is operator-dependent, whereas the tissue function using TENS is patient-dependent [5]. Conventional TENS operates through the gate control theory [6]. The term Ultra-low Frequency (ULF) is used when a frequency of <4 Hz is employed for stimulation [7]. Ultra-low Frequency TENS (ULF-TENS) is thought to act on the muscular component via dromic and antidromic mechanisms, causing contraction of the 7th and 5th pairs of cranial nerves [8]. These cranial nerves supply the masticatory muscles in the face, which play an important role in the border moulding procedure. TENS induces a small electric current that causes controlled twitching of the facial muscles [2].

Meyerowitz WJ reported that 32% of 190 completely edentulous patients experienced pain upon palpation of the masticatory muscles [9]. Therefore, TENS has the added benefit of deconditioning the muscles and relieving masticatory muscle pain. TENS uses four surface electrodes [8], which are placed on the patient's face with self-adhesive tapes to deliver current at variable amplitudes and frequencies [8].

Various studies [3,9-12] have compared different border moulding techniques for resorbed ridges. Many of the techniques employed physiological compression of tissues [9]. Literature indicates that edentulous patients are at a higher risk of masticatory muscle disorders, highlighting the need to record tissue in a functional manner [11]. Although TENS has been previously used in few case reports as an effective border moulding impression technique [13-17], it has not been compared with any available border moulding impression materials or techniques. Therefore, the rationale for present study was to compare different border moulding techniques for their retention.

Three border moulding techniques were employed for each patient: ULF-TENS was used to record a single-step border moulding using polyvinyl siloxane elastomeric border moulding material [18,19]; a final impression was made using light body polyvinyl siloxane elastomeric material. The second technique involved single-step border moulding without ULF-TENS, also using polyvinyl siloxane elastomeric material, followed by a final impression using light body

polyvinyl siloxane elastomeric material. The third technique utilised soft-tissue liners for functional border moulding.

MATERIALS AND METHODS

This non randomised clinical study was conducted in the Department of Prosthodontics and Crown and Bridge at KVG Dental College and Hospital in Sullia, Karnataka, India, from January 2022 to December 2023. The study was approved by the Institutional Ethical Committee (IECKVGDCH/26/2022-23), and informed consent was obtained from all participants. A simple random sampling based on mean difference of a previous study was done.

Inclusion and Exclusion criteria: Patients with a completely edentulous maxilla and mandible aged between 40-70 years were included in the study. Exclusion criteria included patients with severe undercuts, bony exostoses and tori, an extremely high palatal vault, poor neuromuscular control, epilepsy, or cardiac pacemakers.

Study Procedure

For each patient, a primary impression of the upper arch was made using irreversible hydrocolloid impression material to obtain the primary cast [9]. The cast was properly outlined for the fabrication of custom impression trays using cold cure acrylic resin (DPI cold cure, The Bombay Bumrah Trading Corporation Ltd., Mumbai, Maharashtra, India).

Three identical trays with full spacers (Sharry spacer) were fabricated, with two trays measuring 2-3 mm and one tray measuring 1.5-2 mm, each 2 to 3 mm short of the tissue reflection line. Two trays had handles, while one was without a handle. Three impressions were taken from each patient.

Group-A: Total 10 border mouldings were performed using TENS and soft putty polyvinylsiloxane border moulding material, followed by a final impression made with light body polyvinylsiloxane impression material.

Group-B: Total 10 border mouldings were performed using soft putty polyvinylsiloxane border moulding material, with the final impression made using light body polyvinylsiloxane impression material.

Group-C: Total 10 functional border mouldings were performed, and the final impression was made using a tissue conditioner. The patients were recalled after 24 hours for retrieval.

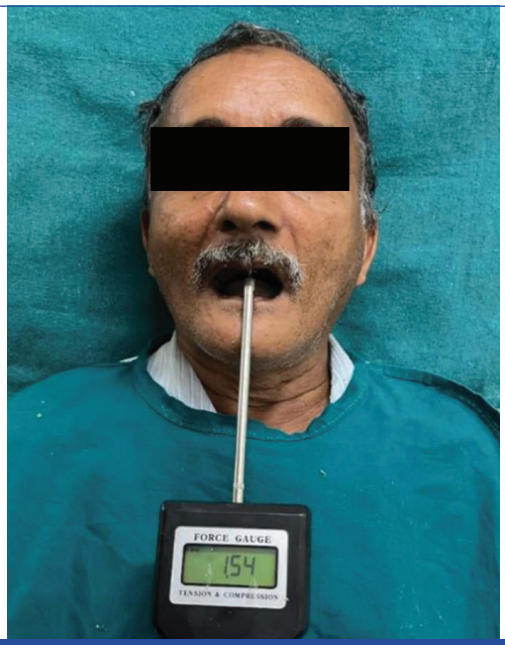
The treatment procedure was thoroughly explained to the patients, and only those who agreed to participate in the clinical trial and signed the informed consent form were included in the study. A break of 30 minutes was provided to the patients before each border moulding session.

Patients were given 20 minutes of TENS (TENS Medi Gray MH8000, Keelung City, Taiwan) adjusted to 4/sec and a frequency of 4 Hz for muscle deconditioning. After the muscle deconditioning, a custom tray, which had a full spacer of 2-3 mm thickness, was lined with polyvinylsiloxane border moulding material (Photosil, dental products of India, Bombay Bumrah Trading Cooperation Ltd., Mumbai). The intensity of the TENS was increased to 7/sec until twitching of the facial muscles was observed, and a single-step border moulding was carried out. The borders were moulded by the twitching of the muscles without any manual movement by the operator. After a 40-minute rest [17], final impressions were made using light body addition silicone impression material (Reprosil, Dentsply, base paste and catalyst paste, hydrophilic vinyl polysiloxane impression material, Mudka Industrial Area, Main Rohtak Road, Delhi).

Using the second tray, which had a full spacer of 2-3 mm thickness border moulding was completed using the single-step border moulding method. This involved soft putty polyvinyl siloxane and light-bodied addition silicone impression material to create the final impression. The third tray, which had a full spacer of 1.5-2 mm thickness, had tissue conditioner (GC Relinetm extra soft, GC Company, Tokyo) applied to it. This tray was then inserted into the patient's mouth and retrieved after 24 hours to collect the impression [20].

Three prefabricated stainless steel loops (0.9 mm) were attached to all three custom trays in the anterior region using self-curing acrylic resin. A digital force gauge [Table/Fig-1] was engaged onto the loop of the custom tray with a secondary impression, and force was applied by pulling it downward while being held in the palm of the operator. The force was directed perpendicularly to the occlusal plane to evaluate retention [Table/Fig-2]. Three readings were recorded for each impression, and the collected data were tabulated and statistically analysed.

[Table/Fig-1]: Lutron force gauge (20 kg).



[Table/Fig-2]: Recording the force required to dislodge the denture bases using digital force gauge.

Beading and boxing were performed, and master casts were obtained [Table/Fig-3]. The arrangement of teeth was completed, and a try-in of each denture was conducted to check for proper fit and speech. Each patient received three heat-cured permanent complete upper dentures and one complete lower denture constructed from three maxillary master casts obtained from three groups in the study [Table/Fig-4]. Subsequently, three prefabricated stainless steel loops were attached to all three heat-cured dentures using self-curing acrylic resin in the anterior palatal region, approximately corresponding to a line joining the distal surfaces of the cuspids and midline (geometric center).

The patient was made to stand upright with the maxilla parallel to the floor, and the digital force gauge was engaged onto the loop

[Table/Fig-3]: Beading and boxing done.

[Table/Fig-4]: Group-coded heat cured dentures.

of the final dentures. Force was applied by pulling it downward while being held in the palm of the operator. The force was directed perpendicularly to the occlusal plane to record retention. The assessment of retention was carried out after the secondary impression and after the fabrication of the dentures to ensure that the values did not vary due to any acrylisation errors. Readings were recorded, and the collected data were tabulated and statistically analysed.

A comprehensive analysis of the patients' responses was recorded using a questionnaire after the retention was measured using the force gauge, following the secondary impression and after the delivery of the final dentures. The questionnaire was self-prepared and contained a total of seven questions for each technique. It was sent to experts in the field for validation. After validation, two questions were removed, resulting in five questions for each technique being used. The reliability was noted to be 0.82.

STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Packages of Social Sciences (SPSS) version 21.0. The significance level was set at ≤0.05. For the comparison of the data, ANOVA statistical technique was employed and randomised control trials were conducted with SD=Standard Deviation- 2.47, Z1-α/2=1.96 at 95% confidence interval, zβ=0.84 at 80% power, d=mean difference=3.30.

RESULTS

In the present study, the retention provided by single-step border moulding with TENS (Group-1), single-step border moulding without TENS (Group-2), and functional Border Moulding (BM) with tissue conditioner (Group-3) was compared among 10 subjects. The patients selected for the study had a mean age of 59.0±4.67 years, with four females and six males, all requiring complete dentures. There was a significant difference between the mean retentive values (kgf) of the three groups of final impressions (p<0.001), as illustrated in [Table/Fig-5]. On pair-wise comparison between the different groups, significantly higher retention was observed in the final impressions made using TENS and putty compared to Tissue Conditioners (TC) (p=0.001, 0.008, respectively) [Table/Fig-6].

Groups	Mean±Std. Deviation	95% CI for mean		Minimum	Maximum	p-value
		Lower bound	Upper bound			
BM TENS	2.58±0.56	2.18	2.99	1.80	3.70	<0.001
BM putty	2.30±0.53	1.92	2.69	1.45	3.04	
BM TC	1.26±0.94	0.59	1.94	0.22	2.70	

[Table/Fig-5]: Comparison of retentive force among the studied groups (in kg) of final impressions.
Test: ANOVA test

(I) Groups	(J) Groups	Mean difference (I-J)	p-value
BM TENS	BM putty	0.27900	0.656
	BM TC	1.31900*	0.001
BM putty	BM TENS	-0.27900	0.656
	BM TC	1.04000*	0.008
BM TC	BM putty	-1.04000*	0.008
	BM TENS	-1.31900*	0.001

[Table/Fig-6]: Group-wise multiple comparison of retentive force among the studied groups using Post-hoc Tukey's test in final impression.
*The mean difference is significant at the 0.05 level

Similarly, a significant difference was observed between the mean retentive values (kgf) of the final dentures of the three groups (p<0.001). The final denture made using TENS and border moulding showing the highest retention [Table/Fig-7]. On pair-wise comparison between the different groups, significantly higher retention was observed in the final dentures made using TENS and putty compared to tissue conditioners (p=0.002, 0.008, respectively) [Table/Fig-8].

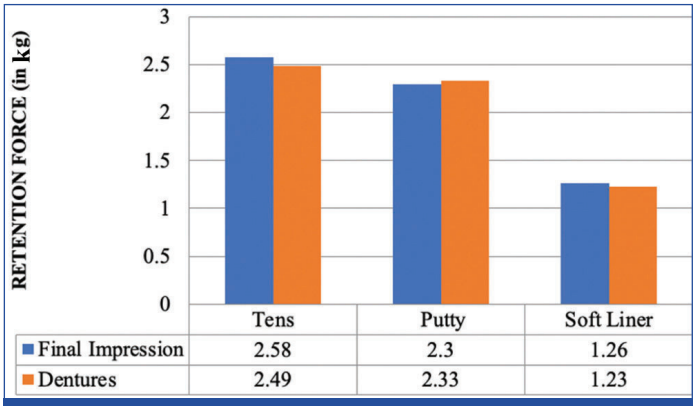
Groups	Mean±Std. Deviation	95% CI for mean		Minimum	Maximum	p-value
		Lower bound	Upper bound			
Final TENS	2.49±0.99	1.78	3.20	1.09	4.80	<0.001
Final putty	2.33±0.45	2.00	2.66	1.50	3.20	
Final TC	1.23±0.69	0.74	1.73	0.45	2.10	

[Table/Fig-7]: Comparison of retentive force among the studied groups (in kg) of dentures.
Test: ANOVA test

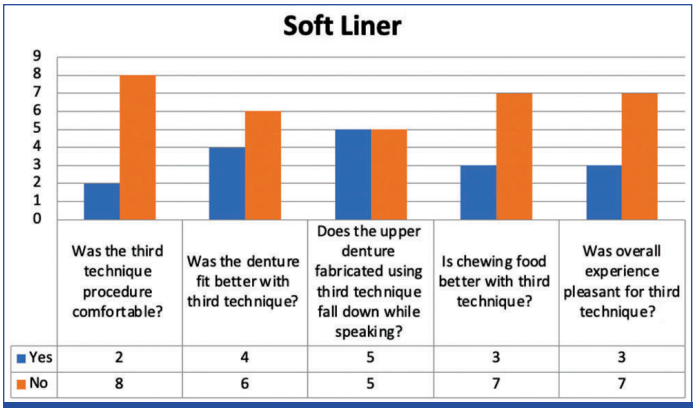
(I) Groups	(J) Groups	Mean difference (I-J)	p-value
Final TENS	Final putty	0.16000	0.882
	Final TC	1.25800*	0.002
Final putty	Final TENS	-0.16000	0.882
	Final TC	1.09800*	0.008
Final TC	Final putty	-1.09800*	0.008
	Final TENS	-1.25800*	0.002

[Table/Fig-8]: Group-wise multiple comparison of retentive force among the studied groups using Post-hoc Tukey's test in dentures.
*The mean difference is significant at the 0.05 level

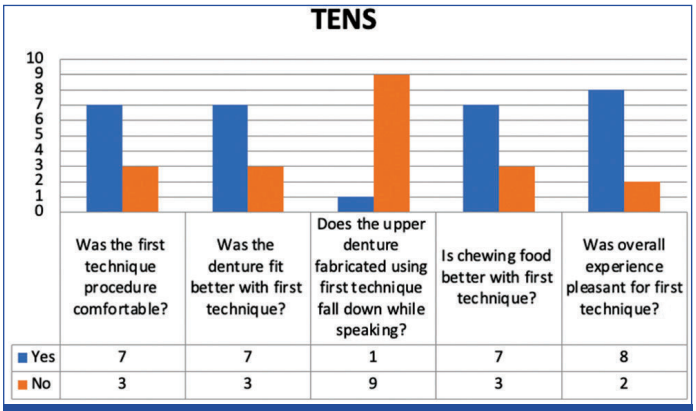
A comprehensive analysis of the patients' responses after the denture delivery using the three different techniques of border moulding-namely Group-A, Group-B, and Group-C-was conducted. Responses regarding comfort, fit of the denture, retention of the denture while speaking, chewing ability, and overall experience were assessed. It was inferred that comfort was better in Group-B. Both Groups A and B demonstrated a good fit of the denture. The retention of the denture, chewing ability, and overall experience were higher in both Groups A and B. [Table/Fig-9-12] show a comparison of patient's responses toward each technique recorded during secondary impression and final denture insertion.



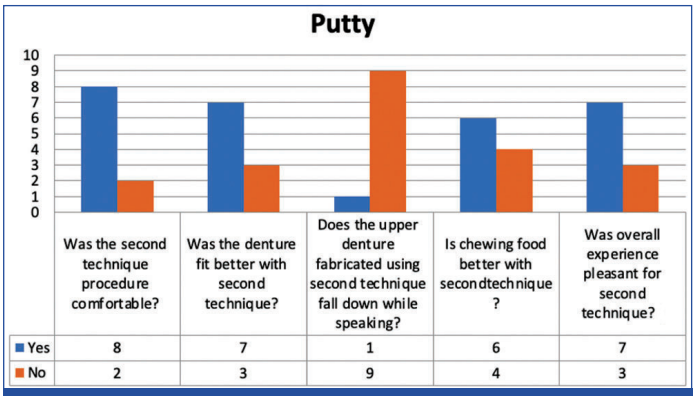
[Table/Fig-9]: Comparison of retentive force among the studied groups (in kg).



[Table/Fig-10]: Comparison of response of patients to dentures given using soft liner.



[Table/Fig-11]: Comparison of response of patients to dentures given using TENS.



[Table/Fig-12]: Comparison of response of patients to dentures given using putty.

DISCUSSION

In present study, it was found that border moulding with TENS using polyvinyl siloxane putty and light body for the secondary impression provided higher retention compared to functional border moulding using a tissue conditioner.

The primary impression should achieve the goals of retention, stability, and functional support, all of which play a vital role in maintaining resorbed ridges [10]. Soft-tissue displacements can range from 2 to 2.5 mm while making an impression [10]. The primary impression made in present study used alginate, which does not compress the underlying mucosa [10]. The use of minimal and selective pressure impression techniques should be employed [11]. Additionally, irreversible hydrocolloid impressions provide refined and detailed surface details [11].

In the present study, light-body addition silicone was chosen for the final impression because it is biocompatible, has good flow behaviour, offers sufficient working time, and provides dimensional accuracy and stability, along with a pleasant colour and odour [4]. The advantage of this technique is that non stress-bearing areas are recorded with minimal pressure, while selective pressure is applied to specific locations that can withstand occlusal forces, as proposed by Boucher [4].

A tissue conditioner was also used for border moulding in present study to compare retention. Jankelson B and Radke JC found that manipulating the cheeks and lips during impression procedures can lead to underextensions of the boundaries when the muscles return to their resting lengths [21]. The tissue conditioner was used to record functional border moulding. Custom trays lined with tissue conditioner were left in patients' mouths for 24 hours to adequately mould the borders [20]. Ideally, physiologic and functional boundaries are recorded with materials that can flow continuously over an extended period. Recent studies [20,22] have shown that it can be left for a period of 24 hours. However, only tissue conditioner possesses this ability among the available materials [20]. Tissue conditioner is a material that flows over time and provides an accurate representation of the border morphology of the tissues, as demonstrated by Abdel Hakim AM et al., [23].

The term ULF-TENS refers to the frequency of current being less than 4 Hz [7]. Compared to traditional TENS, ULF-TENS offers several advantages, including being less invasive, causing minimal side effects, being less technique-sensitive (patients typically self-administer after receiving the necessary training), and being relatively easy to use [5]. There are few studies in which ULF-TENS has been used to record the intaglio surface of denture for better adaptation [13-15].

The frequency of the current delivery rate should be adjusted to 2-4 Hz, and the amplitude should be increased from 0 to 4 based on the patients' tolerance levels and subjective symptoms. Muscle twitching typically begins at 10-12 minutes, and TENS can be applied for a total of 40 minutes [17]. There is no need to perform any manual or functional movements; instead, the surrounding musculature will twitch, allowing the recording material, polyvinylsiloxane, to conform to the sulcus [15]. Additionally, silicone material was loaded into a syringe with the needle hub removed to ensure uniform distribution of the material along the borders [15].

Three aspects contribute to the success of complete dentures: retention, stability, and support [12]. Retention is defined as the inherent quality of the dental prosthesis that resists the forces of dislodgement along the path of placement [24]. As recommended by Burns DR et al., for a more objective assessment, the digital force gauge (Leutron digital force gauge- 20 kg) was the tool of choice for evaluating retention [25]. Placing the loop more anteriorly ensures a force perpendicular to the denture base, rather than the oblique stresses produced when the loop is attached at the geometrical center. This was done to ensure that the definition and guidelines for retention were followed [25-28].

The differences in retention between secondary impressions and dentures obtained through border moulding using putty addition silicone and secondary impressions made using light body silicone, with and without the use of TENS, were statistically not significant. Hence, it can be inferred that TENS may be used only when there is an underlying TMJ disorder and when the usual method of recording border moulding with putty impression material becomes difficult. This is in line with the findings of Yarapatineni R et al., Gupta R et al., Ammar MM et al., and Rizk FN et al., who supported the use of putty consistency addition silicone as a border moulding impression material and light body addition silicone as a secondary impression material [4,18,29,30].

Contrary to the results of present study, Qanungo A et al., investigated and concluded that putty polyvinyl siloxane was less retentive compared to the incremental technique using green stick impression material for border moulding [25]. Chaware SH and Fernandes F conducted a study on flat mandibular ridge cases and discovered that the tissue conditioner caused the least tissue stress to record the border seal area, as it has unidirectional flow characteristics, which led to increased retention and stability of the denture [31,32]. Patel JR et al., concluded in their study that the tissue conditioner was a superior border moulding material compared to pattern resin [21]. Similar studies from the literature have been tabulated in [Table/Fig-13] [14-16,18-20,22,25,26,28,33-35].

S. No.	Author's name and year	Place of study	Number of subjects	Materials compared	Parameters assessed	Conclusion
1.	DSouza RD and Verma S, 2022 [19]	Doha, Qatar	100	• Green stick impression • Polysulphide elastomer • Poly-ether • Polysiloxane impression material	Retention of dentures	Polysiloxane is a superior material for border moulding material
2.	Zarir R et al., 2022 [20]	India	20	• Low fusing compound • Putty addition silicone • Pattern resin • Tissue conditioner	Morphology of the denture borders	Tissue conditioner was the best material that could be used for border moulding followed by pattern resin and low fusing compound
3.	Garg A et al., 2020 [33]	India	15	• Green stick • Putty addition silicone	Retention of denture bases	Two step impression technique is more retentive as compared to one step impression technique
4.	Rajamani VK et al., 2021 [14]	India	Case report	• Low fusing green stick-border moulding • Polyvinylsiloxane- secondary impression material • TENS	Nil	Case report describes recording of border mouldings and cameo surface using Ultra low frequency-TENS (ULF-TENS) in a complete edentulous patient, resulting in enhanced adaptation of dentures
5.	Gowda EM et al., 2021 [16]	India	Case report	• Polyvinylsiloxane elastomeric impression material • ULF-TENS	Nil	ULF-TENS was used as an aid in cameo surface recording and customised magnet retained cheek plumber for rehabilitation with complete denture prosthesis
6.	Jassim TK et al., 2020 [26]	Iraq	10	• Addition vinyl silicone- single step border moulding • Green stick compound	Retention of dentures	Addition vinyl silicone used for single-step border moulding provided superior retention
7.	Pridana S et al., 2019 [28]	Indonesia	10	• The heavy body polyvinylsiloxane (dispensing gun)- • Polyvinylsiloxane putty (mixed manual)	1. Retention of final impression 2. Morphologic detail of peripheral tissue	Putty polyvinylsiloxane with functional technique can be recommended for border moulding procedure
8.	Pachar RB et al., 2018 [35]	India	10	• Green stick impression compound • Putty consistency addition silicone • Polyether impression material	Retention of complete denture	Dentures made using polyether final impression material showed the highest mean values of complete denture retention followed by putty rubber base border moulding with light body final wash
9.	Qanungo A et al., 2016 [25]	India		• Green stick impression compound. (sectional) • Putty consistency addition silicone. (single step)	Retention of heat cure trial denture bases	Sectional border moulding technique proved to be more retentive as compared to single-step border moulding although clinically the retention appeared comparable
10.	Gupta R et al., 2015 [18]	India	20	• Green stick with incremental technique • Heavy bodied polyvinylsiloxane with simultaneous technique	Retention of dentures	Border moulding with heavy bodied polyvinyl siloxane using simultaneous technique provided better retention as compared to border moulding with modelling compound using incremental technique
11.	Kheur M et al., 2015 [34]	India	10	• Low fusing Impression Compound Type I • Heavy bodied Elastomeric Material: Polyvinyl Siloxane • Modified Zinc Oxide Eugenol Impression Paste	• Tissue contact • Bond to the tray • Tissue displacement • Overall peripheral seal	One step border moulding is a viable and advantageous alternative to conventional border moulding (sectional border moulding) as it results in reduction of chairside time, less discomfort for the patient and less efforts for the dentist
12.	Bulbule NS et al., 2013 [15]	India	Case report	• Putty consistency addition silicon • TENS	Nil	Novel, precise and accurate technique of performing border mouldings using TENS
13.	Patel JR et al., 2010 [22]	India	30	• Tissue conditioner • Low fusing impression compound • Putty addition silicon • Pattern resin	Area of sulcus using stereomicroscope	Border area recorded using pattern resin is closest in dimension to that obtained using tissue conditioner
14.	Present study	India	30	• Addition silicon putty with TENS • Addition silicon putty without TENS • Tissue conditioner	Retention of secondary impression and dentures using digital force gauge	Border moulding with TENS using polyvinyl siloxane putty and light body secondary impression provided the higher retention when compared to functional border moulding using tissue conditioner

[Table/Fig-13]: Studies comparing various border moulding materials and techniques for denture retention [14-16,18-20,22,25,26,28,33-35].

Limitation(s)

There are a few limitations in the present study. Firstly, in the case of manual border moulding using putty-consistency addition silicone, this method is effective for moulding the borders. However, when using TENS, medium-body consistency addition silicone would have been more beneficial due to its superior flow characteristics. This is important because muscular twitching can occur during border moulding with TENS, and the flowability of the medium-body material would have better adapted to the contours of the borders. Secondly, although border moulding using TENS and putty yielded comparable retention values, TENS therapy is a time-consuming procedure and may be particularly beneficial for patients with Temporomandibular Joint (TMJ) disorders.

CONCLUSION(S)

In present study, single-step border moulding with TENS therapy using putty-consistency polyvinylsiloxane for border moulding and light-body polyvinylsiloxane impression material for the secondary impression provided the highest retention of both the final impression and the denture when compared to the other groups. The retention was comparable to that of border moulding done with polyvinylsiloxane impression material and light-body addition silicone for the secondary impression, without the application of TENS, and was significantly higher compared to border moulding done using a tissue conditioner. However, comfort was reported to be better without the use of TENS. Thus, it can be concluded that the use of TENS for border moulding can be an alternative

method for recording resorbed ridges in cases where there is an underlying TMJ disorder and where the usual method of recording border moulding with putty impression material becomes difficult. Long-term studies are required to evaluate the effects of TENS on the stability, fit, and comfort of dentures, along with comparisons to the different materials available today.

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