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DIGITAL EVALUATION OF A NOVEL IMPRESSION TECHNIQUE COMBINING CONVENTIONAL AND INTRAORAL SCANS FOR RECORDING ABUSED SOFT TISSUE FOR COMPLETE DENTURE CONSTRUCTION. A CLINICAL CONTROLLED CROSSOVER STUDY

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ABSTRACT

Aim: In the fabrication of complete dentures, intraoral scanners can provide a mucostatic recording of the soft tissues, but they often fail to capture the correct borders extension. Integrating conventional border molding with an intraoral scan could help overcome these scanning challenges.

Methodology: Ten completely edentulous patients with flabby anterior mandibular ridge were selected. All patients received a single maxillary complete denture fabricated using a muco-static impression technique opposing 2 mandibular complete dentures fabricated simultaneously using 2 different impression techniques. Group 1 utilized a conventional selective pressure impression technique, while Group 2 employed a hybrid (Digital-Physical) impression technique. the amount of soft tissue distortion between the 2 impression techniques was assessed on a digital analytical software and visual analogue scales were used to evaluate the patient's satisfaction.

Result: The comparison between both groups and between anterior flabby area and full arch were performed using Paired t test. There was insignificant difference between both impression techniques regarding deviation parameters at the anterior flabby area and the full arch at P=0.7. Patient satisfaction responses showed no statistically significant differences for both groups.

Conclusion: Integrating intraoral scanning with the conventional impression technique can be considered equally effective in recording flabby tissue in a mucostatic condition and producing a satisfying denture, similar to the conventional window technique.

KEYWORDS: Flabby, Intraoral scan, Mucostatic, Selective pressure

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INTRODUCTION

"Flabby ridges" occur due to bone loss, where bone is replaced by connective fibrous tissue, commonly found in the anterior part of the jaw. Regardless of the etiology, research has revealed that approximately 5% of the edentate mandibles and 24% of the edentate maxillae exhibit flabby ridges.[1] Impression making is crucial for creating a functionally and aesthetically successful denture. However, the forces exerted during the impression process can displace the flabby tissue, resulting in a compromised denture in both function and appearance.[2–5] Fabricating a stable and retentive complete denture for patients with fibrous ridges is highly challenging.[6,7] Modified impression techniques are necessary to accurately record the fibrous tissues in their undistorted form, ensuring a stable and functionally satisfying denture. If the flabby tissue is compressed during conventional impression making, it will rebound and cause denture displacement.[8,9]

The selective pressure impression technique combines non-displacive mucostatic and displacive compressive techniques.[7,10–13] Watson[14] described the 'window' impression technique, where a special tray with a window corresponding to the flabby tissue region is used.[10] Initially, a muco-compressive impression is made of the stress-bearing tissues using a custom tray and zinc oxide and eugenol. Once set, it is removed, trimmed, and re-seated in the mouth. A low-viscosity impression material is then applied to the flabby tissues through the window. Once this material sets, the entire impression is removed.[15] In the traditional selective pressure impression technique, plaster is employed to capture the flabby tissue.[9] However, plaster presents difficulties in handling, has a long setting time, and poses a risk of fracture during the pouring procedure.[1] Generally, impression materials exhibit a degree of viscoelasticity, which means that pressure can displace the movable soft tissues.[3]Masri et al[16] reported that the viscosity of the impression material has a direct effect on the extent of pressure created when making the impression. Komiyama et al[17] reported that utilizing modified trays with 1.0 mm holes or 1.4 mm thick relief spaces on maxillary edentulous ridges can selectively reduce pressure. Similarly, Shin et al[2] evaluated the effect of relief spaces, escape holes, and trays with windows on the abused flabby tissues.

Digital technology is increasingly integrated into daily dental practice.[18] Some research has shown that optically scanning large edentulous areas can be challenging due to difficulties in capturing deep landmarks and the posterior palatal seal area with intraoral scanning devices.[19–21] Functional border molding remains essential for recording anatomical landmarks at the denture border area.[20,22,23] While intraoral scans can produce a mucostatic recording of the tissues, they often fail to capture the proper extension.[8,18,20,22,24–28] However, intraoral scanning can capture flabby tissues in a passive state, resulting in a true mucostatic impression. Combining conventional border molding with an intraoral scan could potentially address these scanning issues.[23] The aim of this clinical study is digital evaluation of the flabby soft tissue displacement by combining digital intraoral scans with the conventional impressions, the null hypothesis is selective pressure impression technique through combining digital intraoral scans with the conventional impressions could provide the least tissue displacement.

METHODOLOGY

Ten completely edentulous patients, aged between 45 and 70 years, were selected from the outpatient clinic of the Prosthodontic Department at the Faculty of Dentistry, Cairo University. According to a previous study[29], the minimally accepted sample size was 8 patients, when mean ± standard deviation of the digital group was 0.29 ± 0.03 while estimated mean difference was 0.035, when the power was 80 % & type I error probability was 0.05. The Paired t test was performed by using P. S. power 3.1.6. With the aid of a blunt metal instrument, all recruited patients were examined by

a single operator for the presence of hypermobile tissues near the crest of anterior mandible **Fig** 1(a). To be included in this study, patients had to meet the following criteria: Angle's Class I ridge relationship with well-developed residual alveolar ridges, except for a localized flabby tissue at the crest of the lower arch anteriorly. Patients who were noncompliant, had parafunctional habits, neural disorders, or uncontrolled diabetes were excluded from the study. The study was approved by the Research Ethics Committee of the Faculty of Dentistry, Cairo University, under approval code (20-9-2023). All procedures were conducted after informing the patients about the nature and details of the study and obtaining their signed informed consent.

All patients received a single conventionally fabricated maxillary complete denture opposing 2 mandibular complete dentures fabricated simultaneously using 2 different impression techniques. Group 1 utilized a conventional selective pressure impression technique, while Group 2 employed a hybrid (Digital-Physical) impression technique. All steps for complete denture construction for both groups were identical, except for the mandibular data acquisition procedure. Maxillary and mandibular preliminary impressions were registered using an irreversible hydrocolloid impression material (Hydrogum 5, Zhermack, Italy) in stock trays obtain the study casts. Maxillary secondary impression was obtained using 2-stage putty and medium consistency PVS impression materials (Elite HD+, Zhermack, Italy) on a customized tray and a master model was obtained.

A customized mandibular tray was created with an anterior window **Fig** 1(b), designed to be used for both impression groups. In Group 1, the impression

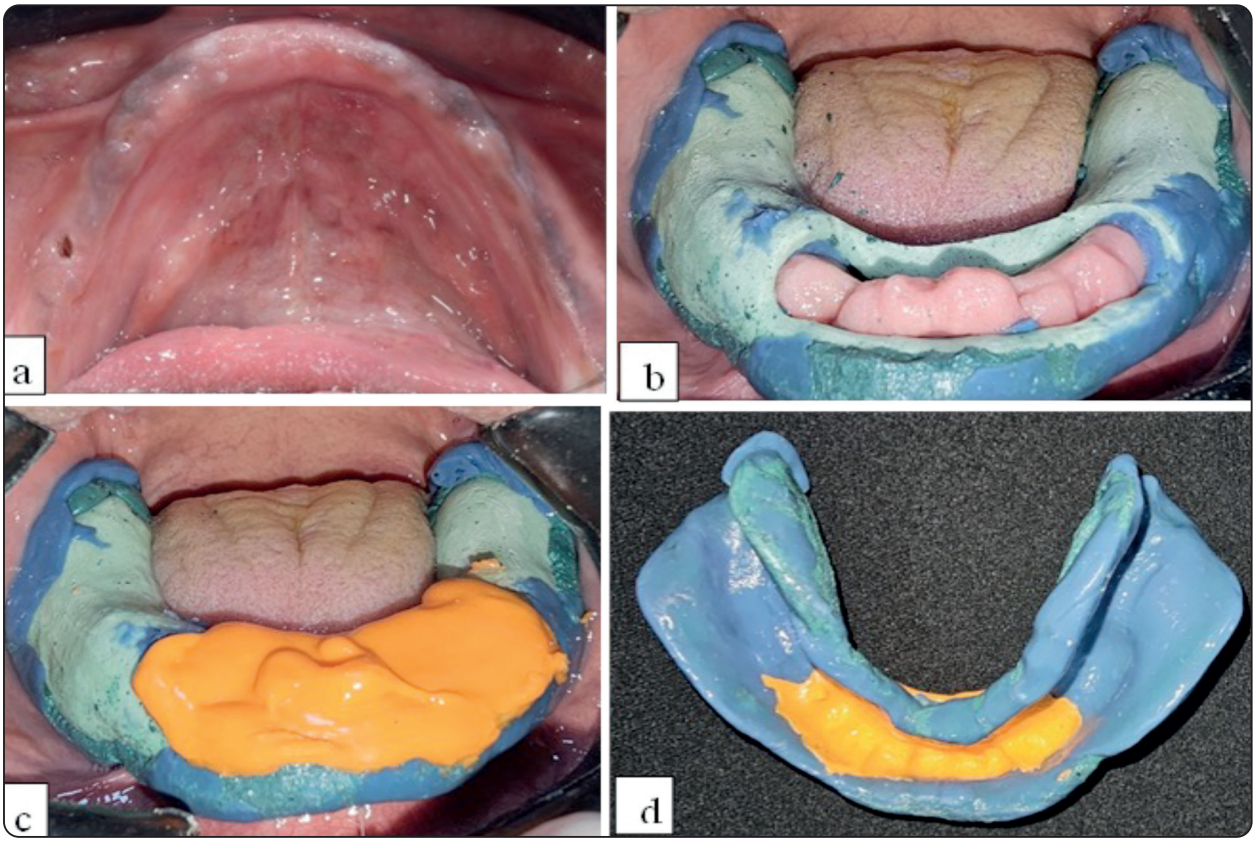

Fig. (1) (a) Mandibular arch with anterior flabby tissue. (b)Modified special tray with window over the flabby tissue. (c) Intraoral view of border molding and final impression (Group1). (d) Extraoral view of the selective pressure impression with light consistency PVS impression material recording the flabby tissue.

process involved two-stage putty and medium consistency PVS impression materials (Elite HD+, Zhermack, Italy) to capture the posterior area of the mandibular arch, as well as the buccal and lingual borders **Fig** 1(c), excluding the anterior flabby tissue. After the impression material had fully set, while the tray remained in place, a light consistency PVS impression material (Elite HD+ super light, Zhermack, Italy) was injected over the anterior flabby tissue using an intraoral automix tip **Fig** 1(d). Once the material had set completely, the impression tray was removed and left aside for immediate use in the Group 2 impression procedure. Using an intraoral scanner (Medit I700, Medit, Korea) an optical impression was done for the mandibular arch **Fig** 2(a). Data acquisition focused solely on the crest of the ridge, excluding the depth of the buccal and lingual vestibules. The scan was performed under adequate moisture control with the patient seated upright and their cheeks and lips gently retracted. The scanning process began from the anterior flabby tissue to the retromolar pad on the right side, then moved back anteriorly towards the retromolar pad of the left side.[20] Using Medit Scan software (Medit link, Medit, Korea), any unnecessary scanned data involving the cheeks, lips, tongue, and lateral walls of the residual alveolar ridge were deleted with the brush tool of the trimming option. To prevent data loss or distortion during further software manipulation, the scanned areas of interest was locked using the brush tool of the locking option.

A particularly useful feature available in the updated version of the Medit software is the ability to augment the imperfect intraoral scan with an extraoral scan of the physical impression. This enables scanning parts of the physical impression that were not successfully captured using the intraoral scanner, with the software automatically combining the data from both scans into a single successful scan. Using the impression scan tool, the missing areas of the mandibular arch, including the lateral walls of the residual alveolar ridge, the depth of the vestibules, the impression borders, and the distal area of the retromolar pads, were completed by scanning the previously obtained physical impression. Mandibular models for both groups were obtained after pouring the obtained physical impression (Group 1) into dental stone type 2 (Elite Stone, Zermach, Italy) and 3D printing the exported STL file of the mandibular hybrid scan (Group 2)using an LCD 3D printer (Anycubic Photon MonoX, AnyCubic, China) **Fig** 2(d). All steps for complete denture fabrication were completed conventionally for both groups including the jaw relation records, artificial teeth arrangement and try in. On the day of denture delivery, each patient received a single maxillary and 2 mandibular dentures which were checked simultaneously for fit, borders, extensions and occlusion. Group 1 dentures were initially delivered to the patients, who were blinded to the type of denture received. After 3 months of functional denture use and a washout period of 48 hours, Group 2 dentures were delivered. Each patient was allowed to fill a questionnaire at T0 and T3.

Visual analogue scales were used to evaluate the patients' overall satisfaction with the mandibular dentures employing the 100mm scale. Following the study of Soboleva et al[19] , an overall satisfaction with dentures ,comfort, ability to speak and chew, denture aesthetics, stability, and ease of prosthesis cleaning were evaluated. The following questions were considered: Q1) Are you satisfied with your dentures? ('very dissatisfied' to 'very satisfied'); (Q2) Do you feel comfortable using dentures? ('absolutely no' to 'perfectly comfortable'); (Q3) Are you happy with the way you look with your dentures? ('very dissatisfied' to 'very satisfied'); (Q4) Can you chew the food? ('very badly' to 'very good'); (Q5) Do your dentures cause any trouble when speaking? ('very large disturbances' to 'absolutely none'); (Q6) Are your dentures stable? ('very unstable' to 'very stable'); (Q7) Is everyday care of your dentures easy to provide? ('very difficult' to 'very easy').

This questionnaire was translated into Arabic by two certified translators and then back into English by two other certified translators. Subsequently, ten multilingual volunteers were given both the English and Arabic versions in alternating order for evaluation. Post-insertion follow-up visits were scheduled at one week then monthly during the study period. Additionally, the amount of soft tissue distortion was compared between the 2 impression techniques on a specialized analytical software (Medit designs, Medit Link, Medit Korea). This was employed after scanning the master model obtained from the physical impression (Group 2) using a bench scanner (DOF Freedom UHD Scanner, DOF, Korea) and importing the resultant STL file along with the STL file of Group 2 scan data to Medit Design software. Initially, all irrelevant scanned data was trimmed using the software's cut tool. The relevant scan data from each group were aligned using the software's first three-point-fit and best-fit protocols **Fig** 2(b).. This alignment mode provides a color map to display the degree of qualitative symmetry between the scanned objects: green indicates no deviation, yellow, orange, and red indicate outward deviations, and various shades of blue indicate inward deviations **Fig** 2(c). The quantitative measurements of deviations between the two scans were assessed using root mean square (RMS), average positive, average negative, and standard deviation values, all calculated directly by the software. These quantitative data were recorded, tabulated, and statistically analyzed.

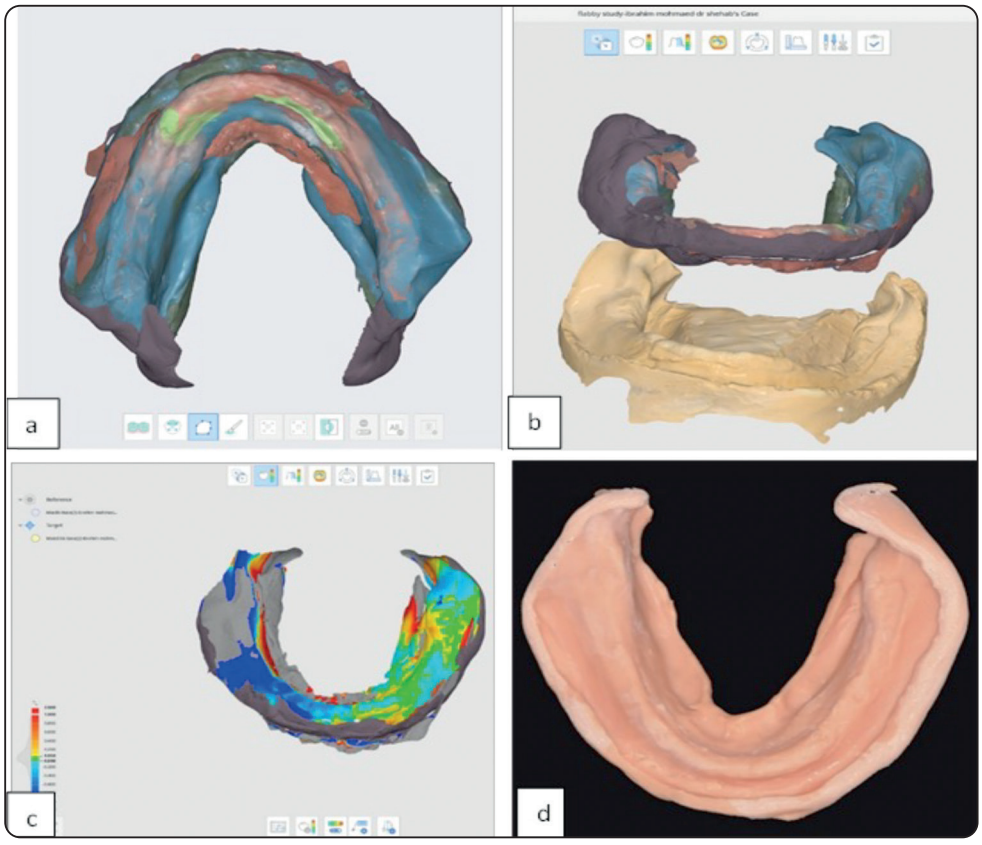

Fig (2) (a): Hybrid impression (Group 2) combining intraoral scan of anterior flabby tissue and extraoral impression scan of the borders. (b) best fit alignment of virtual master models of both groups . (c)Digital color map for soft tissue deviation between both groups. (d) 3D printed mandibular resin model of Group 2

RESULT

Statistical analysis was performed with SPSS 20®*, Graph Pad Prism®** and Microsoft Excel 2016*. Data revealed as minimum, maximum, median, means, standard deviations and standard error of mean. Exploration of the quantitative data was performed using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality which revealed that the significant level (P-value) was insignificant as P-value > 0.05 which indicated data originated from normal distribution (parametric data). Accordingly, the comparison between both groups and between anterior flabby area and full arch were performed by using Paired t test.

Tissue deviation was evaluated using descriptive results of RMS, average +, and average– among anterior flabby ridge and full arch were presented in table (1). Comparison between them was performed by using Paired t test which revealed that there was insignificant difference between them as P=0.7, 0.44, and 0.66 regarding RMS, average+, and average– respectively. Descriptive results of satisfaction, comfort, Aesthetics, chewing, speech, stability, clean in both groups were presented in Fig (3). Comparison between them was performed by using Paired t test which revealed that there was insignificant difference between them as P= 0.18, 0.06, 0.06, 0.61, 0.34, 0.36, and 0.17 regarding satisfaction, comfort, Aesthetics, chewing, speech, stability, and clean respectively.

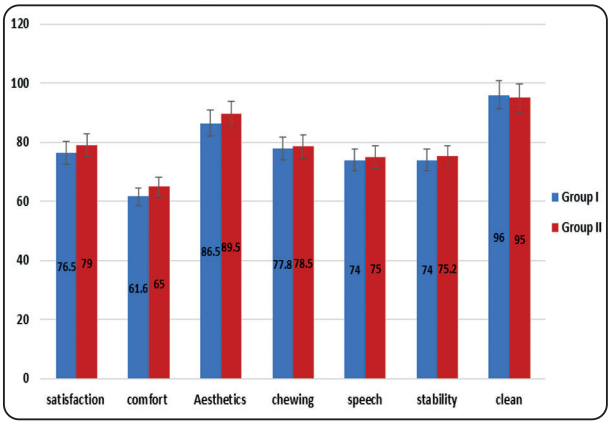

Fig. (3): bar chart representing patient's satisfaction parameters in both groups.

TABLE (1) Descriptive results of RMS, average +, and average – among anterior flabby ridge and full arch, comparison between them using Paired t test:

		Descriptive results						Paired Differences					P value
								Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
		Min	Med	Max	M	SD	SEM				Lower	Upper	
RMS	Full arch	0.28	0.47	0.76	0.49	0.18	0.06	-0.04	0.29	0.09	-0.24	0.17	0.70
	Anterior Flabby	0.22	0.42	0.70	0.45	0.16	0.05						
Positive	Full arch	0.25	0.34	0.55	0.35	0.11	0.04	-0.05	0.18	0.06	-0.17	0.08	0.44
	Anterior Flabby	0.20	0.30	0.46	0.31	0.08	0.03						
Negative	Full arch	0.18	0.29	0.49	0.34	0.12	0.04	0.03	0.22	0.07	-0.12	0.18	0.66
	Anterior Flabby	0.15	0.33	0.65	0.37	0.18	0.06						

* Statistical Package for Social Science, IBM, USA.
** Graph Pad Technologies, USA.
*** Microsoft Co-operation, USA.

DISCUSSION

The current study aimed to capture the flabby fibrous tissue of the mandibular edentulous arch without applying pressure by employing a novel impression technique that combines physical and digital methods. The study compared the accuracy of recording the mandibular edentulous ridge with anterior flabby tissue using both the conventional window technique and the hybrid technique, as well as evaluating patient satisfaction. Based on the study results, the null hypothesis was accepted, indicating that all patients reported similar levels of satisfaction with both mandibular dentures. There were no statistically significant differences in the deformation of flabby and healthy tissues among the two impression techniques.

Since the 1930s, various clinicians have documented the concept of the selective minimum pressure impression technique for recording flabby tissue. This includes Devlin's technique, Hobkirk's technique, Osborne's technique, Filler's modified tray with a mesh design, and the New Tunnel Spacer technique.[2,3,15,17,30–33,4–7,10,11,13,14] However, there is no evidence to support that one particular impression technique provides a stable and retentive denture on flabby ridges as compared to others. In the current study, light body PVS material with the window technique was employed for recording the flabby tissue. Although the plaster impression is regarded the gold standard for this technique, the light body PVS was preferred by several authors[1,15,34,35] for its availability and ease of application.

In an attempt to assess the degree of deformation of the flabby tissue using both impression techniques,[4,9,29] and given the lack of a reference model for comparison, the mean RMS (Root Mean Square) of the aligned virtual models from the two techniques was analyzed for both the anterior and posterior sites. The results yielded no statistically significant difference in the deviation values of the anterior flabby tissues ranging from 0.22-0.42mm. This represents the actual difference in deformation between the conventional window and direct intraoral scanning technique at the flabby tissue zone. Similarly, no significant differences were observed in the RMS values (0.28-0.48) of the full arch models which indicates that the impression scanning technique of the healthy posterior arch in group 2 didn't not influence the amount of tissue deformation.

While the precision of digitizing fully edentulous stone models have been found to be as reliable as traditional stone casts with an accuracy of up to 10 μm[28], published data on intraoral scanning of soft tissue morphology is very limited. Besides the benefits of reducing the gag reflex and overcoming the limitations of limited mouth opening, intraoral scanning has the ability to record the flabby tissues in a true mucostatic state.[18,21,28] Since digital images can be stitched together, capturing all details in a single scan is unnecessary. This approach allows for easier tongue control and moisture management in one area rather than across the entire arch[27].

Intraoral scanning of the mandible is usually more difficult than the maxilla and in some instances may not be even scannable.[24,25,27,36] However, any inaccuracies that may be incorporated in the scanning of edentulous arches are believed by some clinicians[20] not to affect the retention or stability of the dentures fabricated. This aligns with the results of the current study where all patients demonstrated positive responses to their dentures regardless to their group. Conversely, the study of EL Kafrawy et al[22] compared the health of flabby tissue beneath two maxillary dentures and reported statistically significant differences favoring the conventional impression group.

In the previously proposed intraoral scanning techniques for edentulous ridges, it was only possible to scan the labial and buccal borders along with the ridge crest and a portion of the lingual extension, while the remaining portions of the lingual vestibule were obtained with future denture relining procedures.[20,25] In the current study, our novel hybrid

data acquistion technique allowed the recording of the buccal and lingual vestibules in their functional state simultaneously with the flabby tissue in its true mucostatic state without the need for any major border modifications during or after final denture delivery. Similarly, Hong et al in 2019 [23] introduced a technique combining the conventional and digital scans for recording flabby tissue, however their proposed technique involved an additional extraoral scan of the outer and inner surfaces of the impression tray using a desktop scanner.

To assess a new impression technique, it's crucial to consider patient-related outcomes such as satisfaction and post-insertion complaints, alongside its accuracy.[19] Our research focused on patient perception by asking specific questions and recording responses, which were rated on a Visual Analog Scale (VAS) from 0 to 100. Generally, all study patients who returned the completed questionnaire tended to agree with the overall acceptance of the delivered dentures across the seven items listed in the questionnaire. Regarding denture stability, comfort, chewing, and speech, all patients reported acceptable and comparable outcomes for both denture groups. These findings suggest that both techniques are equally effective in recording the flabby tissues without causing excessive deformation, and within the acceptable tolerance levels of the patients. However, these results does not align with other studies that have that have noted significantly higher patient perception and satisfaction with digitally fabricated dentures compared to conventional ones. In our study, all denture fabrication steps for both groups were conducted conventionally, except for the data acquisition technique. Additionally, all patients were blinded to the type of denture being delivered, which supports our contrasting findings. The highest scores were recorded for domains not related to the study variables or patients' ridge conditions, such as denture aesthetics and ease of cleaning, showing no statistically significant differences between the two denture groups.

In the literature, patient satisfaction with dentures has been linked to various factors, including age, sex, prosthetic experience, and psychological factors, which were not considered in the current study. Individuals with previous denture experience or who were current denture wearers may have different perceptions or acceptance levels of new dentures. This, combined with the study's limited sample size, could be considered a limitation and may have influenced the statistical significance of the findings. Although this proposed technique does not eliminate the need for physical impressions, it may be regarded as a milestone in simplifying the integration of both acquisition methods, limiting physical impressions to inaccessible and functionally recorded areas, thereby simplifying the physical impression procedure and relying primarily on intraoral scanning for edentulous ridge records.

CONCLUSION

Integrating intraoral scanning with the conventional impression technique can be considered equally effective in recording flabby tissue in a mucostatic condition and producing a satisfying denture, similar to the conventional window technique. However, further studies with larger sample sizes and incorporating advances in digital technology are necessary.

Conflict of interest

The authors declare no conflict of interest, financial or otherwise.

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