Cumhuriyet Dental Journal, 26(3): 345-352, 2023
DOI: https://doi.org/10.7126/cumudj.1241027

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

Comparing Facial Esthetic and Volumetric Changes of an Edentulous Patient After Either Conventional or Neutral Zone Technique

Ulku Tugba Kalyoncuoglu[1-a], Nurten Baysal[1-b], Ezgi Atik[2-c]

[1] *Department of Prosthodontics, Gulhane Dentistry Faculty, University of Health Sciences, 06010, Ankara, Türkiye.*
[2] *Department of Orthodontics, Faculty of Dentistry, University of Hacettepe, 06100, Ankara, Türkiye.*
**Corresponding author*

Case Report

History

Received: 22/02/2023
Accepted: 28/07/2023

ABSTRACT

The aim of the present case report was to compare the soft tissue measurements, and volumetric differences on the face of the patient whose complete dentures were fabricated either with conventional or neutral zone impression techniques. Two different complete dentures were fabricated according to conventional and neutral zone impression techniques. The measurement of soft tissue changes was evaluated on lateral cephalograms; conventional technique (L1), neutral zone technique (L2) and with no dentures (L3). Three images (I) were taken on the same day respectively with dentures completed by conventional technique (I1), dentures completed by neutral zone technique (I2), and with no dentures (I3). The superimposition of the images was evaluated. The cephalometric soft tissue measurements of the present case showed that upper and lower lips were positioned anteriorly in both conventional (L1) and neutral zone techniques (L2) on the sagittal plane. These results could be attributed to the fact that the placement of the prosthesis in the mouth helps direct lip position with big linear measurements. Volumetric difference between conventional (I1) and no denture (I3) images was more pronounced compared to neutral zone (I2) superposition with no denture (I3).

Key words: Facial Esthetic, Neutral Zone, Complete Denture, Lateral Cephalometric Measurement, 3dMD.

Dişsiz Bir Hastada Konvansiyonel veya Nötral Zon Tekniği Sonrası Fasiyal Estetik ve Hacimsel Değişikliklerin Karşılaştırılması

ÖZ

Bu vaka raporunun amacı konvansiyonel ve nötral zon teknikleriyle tam protezleri yapılan bir hastanın yüzdeki yumuşak doku ölçümleri ve volumetrik değişimlerinin kıyaslanmasıdır. Hastaya konvansiyonel ve nötral zon ölçü teknikleri ile 2 tam protez yapılmıştır. Yumuşak doku değişimleri lateral sefalogramda 3 ayrı şekilde değerlendirilmiştir: (L1) konvansiyonel teknik ile yapılan protez ile, (L2) nötral zon tekniği ile yapılan protez ile, (L3) protez kullanılmazken. Aynı gün, hastadan konvansiyonel teknik (I1) ile yapılan protez ile, nötral zon tekniği (I2) ile yapılan protez ile ve protezsiz iken (I3) yüz görüntü kayıtları alınmıştır. Görüntülerdeki superimpozisyonlar değerlendirilmiştir. Yapılan sefalometrik yumuşak doku ölçümlerine göre sagittal düzlemde konvansiyonel (L1) ve nötral zon tekniği (L2) ile yapılan protezleri taktığında, hastanın üst ve alt dudağının daha önde konumlandığı tespit edilmiştir. Bu durum protezlerin takıldıklarında dudağı yönlendirmesi ile açıklanabilir. Hacimsel farklılıklar, konvansiyonel (I1) ve protezsiz (I3) görüntü çakıştırmalarında, protezsiz (I3) ve nötral zon tekniği (I2) çakıştırmasına göre daha belirgin bulunmuştur.

Süreç

Geliş: 23/02/2023
Kabul: 28/07/2023

Anahtar Kelimeler: Fasiyal Estetik, Nötral Zon, Tam Protez, Lateral Sefalometrik, 3dMD.

a ulkutugbaterzi@gmail.com https://orcid.org/0000-0002-7444-9623 b nurtenerdogan7@hotmail.com https://orcid.org/0000-0003-0634-2012
c ezgibaytorun@hotmail.com https://orcid.org/0000-0002-7444-9623

How to Cite: Kalyoncuoglu UT, Baysal N, Atik E. (2023) Comparing Facial Esthetic and Volumetric Changes of an Edentulous Patient After Either Conventional or Neutral Zone Technique, Cumhuriyet Dental Journal, 26(3):345-352.

Introduction

The tongue, cheeks, and lips are the source of muscular forces that collectively specify the teeth positions and eventual dental arch form in the oral cavity. The effects of these muscular activities intensively influence the volume of the oral cavity space and continue throughout life even after tooth loss.[1] "Neutral zone" is defined as the potential space between the lips and cheeks on the buccal side, and the tongue on the lingual side. In this space, the forces between the tongue and cheeks or lips are equal.[2] Knowledge of the neutral zone concept provides advantages when fabricating complete dentures for the patients that have severely atrophic mandible. The technique helps us in placing the teeth and shaping the polished surfaces of the prostheses.[3] Therefore patients with partial glossectomy, mandibular resections or motor nerve damage, etc. can take advantage of this neutral zone treatment option.[1] In previous studies various techniques, for recording the neutral zone which maintains the polished surface of mandibular dentures, have been described.[4-6] Tissue conditioners, resilient lining materials, impression compounds, soft waxes and, silicones have been recommended for recording the neutral zone.[3]

Many studies exist in the literature that compared patient comfort in complete dentures fabricated with the neutral zone concept and dentures fabricated with conventional techniques. It has been shown that neutral zone dentures are functionally more stable than conventional ones.[3,6] Considering that conventional and neutral zone techniques can make differences in terms of soft tissue functions, it is important to evaluate and compare the changes of the soft tissue in the lower anterior facial region between these two techniques. To the best of our knowledge, there is no study encountered in the literature comparing conventional and neutral zone techniques with respect to soft tissue changes in a clinical report.

The aim of the present case report was to compare the functional ease of use, soft tissue measurements, and volumetric differences on the face of the patient, whose complete dentures were fabricated either with conventional or neutral zone impression techniques.

Clinical Report

A 70-year-old female patient was referred with the complaint of functional disability of her mandibular complete denture. The clinical examination revealed a misfit between the base of the mandibular denture and the denture-bearing mucosa, combined with phonetic problems originating from the maxillary denture and advanced mandibular ridge resorption associated with loss of vertical dimension (Figure 1). For the treatment of the patient, it was decided to fabricate a new complete denture with the neutral zone impression technique to improve the stability and functions of the prosthesis. The dentures fabricated with the neutral zone technique will improve the oral functions of the patient however we do not have any information about the esthetical changes that will be affected. Therefore, it was decided to prepare one more complete denture according to conventional technique. Thus, the soft tissue changes and volumetric differences of the patient could be seen.

After clinical examination, primary impressions for both the two dentures were made using a high-viscosity irreversible hydrocolloid impression material (Alginmax, major Prodotti Dentari S.P.A, Italy). Then two close-fitting custom-made impression trays were prepared with autopolymerizing polymethylmethacrylate resin (Orthoresin; Dentsply, Milford, DE). After that secondary impressions were prepared with zinc oxide eugenol impression material (SS White Mfg, Gloucester, England). The obtained impressions were poured with dental stone (Lab Stone Heraeus Kulzer, South Bend; IN). Acrylic resin plates were fabricated both for the upper and lower jaws for both dentures. Different from the conventional technique, the occlusal rim was adjusted only to the upper plate to support the upper lip to provide occlusal plane, and phonetics when recording the neutral zone impression. Midline, canine lines, and smile line were marked at the clinical try-in appointment for both dentures. After checking the mandibular base plate in the mouth, the patient was ready to start for neutral zone impression with tissue conditioner material (Visco-gel, Dentsply Ltd., Weybridge, U.K.)

The patient head table was adjusted in an upright position with the head supported comfortably, before starting the neutral zone impression. The patient was told to wear her previous maxillary denture to do the functional movements more comfortably than the maxillary occlusal rim. The mandibular base plate was placed to the ridge and the tissue conditioner in fluid viscosity was put bilaterally to the molar region of the mandible. When the tissue conditioner was getting hardened to simulate the physiological functions the patient was asked to swallow, speak, suck, purse lips, pronounce vowels, and slightly protrude the tongue several times. These actions are repeated for 10 minutes until the material is completely hardened. After the shaping of the molar region, the same procedure was applied both to the premolar and incisal regions (Figure 2). When the impression was completed, the base plate was removed and adapted to the master stone model. The impression of the neutral zone on the master model was removed, and locating grooves were prepared (Figure 3). A dental stone index of the model and the impression was taken to preserve the space of the neutral zone record. The tissue conditioner was removed and melted laboratory wax was poured into the negative space that belongs to the neutral zone. Occlusal vertical dimension and intermaxillary relationship record was transferred to a semi-adjustable articulator (Hanau Wide Vue II, Buffalo, NY). The artificial teeth were aligned according to the records of the neutral zone. Functional bite records were checked after the confirmation of centric relation in the clinic. After receiving the opinion of the patient about the esthetic and functional status of the try-in teeth, the

dentures were finished in the conventional technique. After the final clinical adjustments, both dentures were delivered to the patient. The extraoral and intraoral photos of the patient with conventional and neutral zone dentures are shown in Figures 4 and 5.

The measurements of soft tissue changes were applied using conventional lateral cephalograms (L) respectively taken with conventional technique (L1), neutral zone technique (L2), and with no dentures (L3) (Figure 6). Dolphin software (Dolphin Imaging Systems, Chatsworth, Calif) was used for the measurement of soft tissue changes on L. These measurements were made by one orthodontist (E.A.) previously calibrated.

The 3D images were taken in a separate room under standard light using the 3dMDface™ (3dMD Ltd, Atlanta, GA, USA) imaging system. Three images were taken with the patient sitting on a chair with adjustable height, without glass or any other equipment on the examined region. The patient wore a cap to expose the front and the external auditory meatus. The patient directed her chin slightly upwards with her eyes open. Three images (I) were taken on the same day respectively with dentures completed by conventional technique (I1), dentures completed by neutral zone technique (I2), and with no dentures (I3). 3dMDvultus™ (3dMD Ltd, Atlanta, GA, USA) software was used to perform superimposition of the images. After the images were manually aligned using the same software, automated superimposition procedures were applied. Two superimpositions were calculated which were respectively, conventional superposed with no dentures and neutral zone superposed with no dentures. We aimed to determine the changes in the facial contour for the same patient after wearing two different dentures. 3dMD histogram images are shown for both superimpositions in Figure 7. The root mean square (RMS) was considered accurate as 0.02 taking into account a reference article.[7] Volumetric and surface area differences were calculated automatically using software difference surface calculations.

On lateral cephalometric analysis total of 15 linear, 3 angular, and 2 ratio measurements are taken to determine soft tissue facial changes after wearing dentures. The results of the sagittal position of the upper and lower lip measurements are presented in Table 1. The upper lip was positioned 5.4 mm anteriorly related to the Sn-Vertical Line in L1 and 3.9 mm in L2, while it was 0.5 mm in L3. According to E-Line, the upper lip was positioned at -8.2 mm in L1 and -11.1 mm in L2, while positioned at -15.3 mm in L3. UL-SnPg' distances were measured respectively 1mm for L1, -0.7 mm for L2, and -4.1 mm for L3. Upper lip thickness to A point was 14.7 mm for L1, 14.1 mm for L2 and, 10.2 mm for L3. Lower lip was positioned 5.9 mm anteriorly related to the Sn-Vertical Line in L1 and 4.6 mm in L2, while it was 1.1 mm in L3. According to E-Line, the lower lip was positioned at -7 mm in L1 and -9.9 mm in L2, while positioned at -14.5 mm in L3. LL-SnPg' distances were measured respectively -0.2 mm for L1, -1.9 mm for L2, and -5.2 mm for L3.

The results of the vertical position of the upper and lower lip were also presented in Table 1. Upper lip length measurements (Sn-Stms) were respectively 20.3 mm, 22.6 mm and, 19.6 mm for L1, L2, and L3; while lower lip length measurements (Stmi-Me') were respectively 40 mm, 43.1 mm, and 37.1 mm for L1, L2 and, L3. Interlabial gap measurements were almost the same for all three groups, which were respectively: 1.5 mm, 1.2 mm, and 1.1 mm for L1, L2 and, L3.

Upper and lower sulcus and chin measurements for the three groups were also presented in Table 1. Subnasale to H-Line measurements were respectively 1.5 mm, -1 mm and, -5.8 mm for L1, L2 and, L3; while inferior sulcus to H-line was respectively 4.3 mm, 4.7 mm, and 2.3 mm for L1, L2 and, L3 groups. Superior sulcus depth according to Holdaway analysis was 5.4 mm, 3.5 mm and, 1.4 mm respectively for L1, L2 and, L3 groups. Soft tissue chin thickness for L1, L2, and L3 were respectively 12.5 mm, 14.1 mm and 13 mm. Soft tissue pogonion was positioned anteriorly 10.9 mm for L1, 12.9 mm for L2 and 15 mm for L3 according to Sn-Vertical line.

Soft tissue vertical measurements and convexity angle measurements are shown in Table 1. Facial convexity degree was higher in L1 (-4.5°) than L2 (-5.9°) and L3 (-16.8°). Nasolabial angle degrees were 97.1°, 96.5° and 104.9° respectively for L1, L2 and L3. H-angle was lower in L3 (-16.6°), than L1 (-0.1°) and L2 (-4.2°). Vertical soft tissue rate measurements were as following: Sn-Stomion/Stomion-Me ratio was 60.1 for L1, 65.2 for L2, and 54.8 for L3. G'Sn/SnMe' ratio was almost the same for L1 (1), L2 (0.9), and L3 (1.1).

3dMD software volume and surface area comparison was presented in Table 2. According to the results of the software comparison, the area difference between conventional (I1) and no denture (I3) images showed 2033.640 cm^2, and the volumetric difference between conventional (I1) and no denture (I3) images showed 129.634 ccs. The root mean square difference between I1 and I3 was 2.61 (-53.17- 56.01). Neutral zone (I2) superposition with no denture (I3) showed 2116. 242 cm^2 area difference, 63.969 cc volumetric difference and 2.44 (-24.30- 19.46) root mean square difference. After the prosthesis had been delivered to the patient, firstly the patient used the neutral zone complete dentures. The recall sessions were arranged for 1 day, 1 week, and 3 weeks later. After eight weeks use of the neutral zone dentures were replaced with conventional dentures, and the same recall sessions were arranged for conventional dentures. However, the patient was referred to the clinic with major complaints after three weeks of use of the conventional dentures and stated that the neutral zone dentures were more comfortable.

Figure 1: Extra oral photos of edentulous patient.

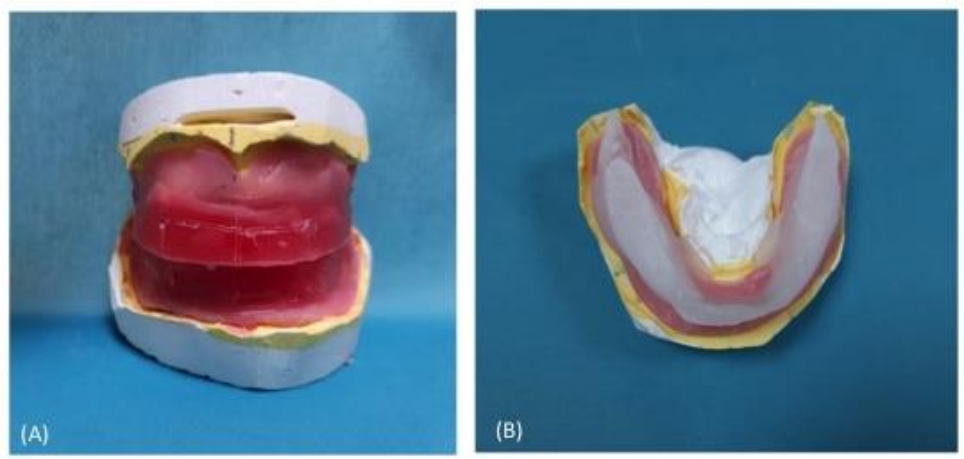

Figure 2: **A:** Occlusal rims for conventional denture; **B:** Mandibular base plate with tissue conditioner for neutral zone impression.

Figure 3: Laboratory stages of neutral zone impression.

Figure 4: Extra oral and intraoral photos of patient after wearing denture that fabricated with conventional technique.

Figure 5: Extra oral and intraoral photos of patient after wearing denture that fabricated with neutral zone technique.

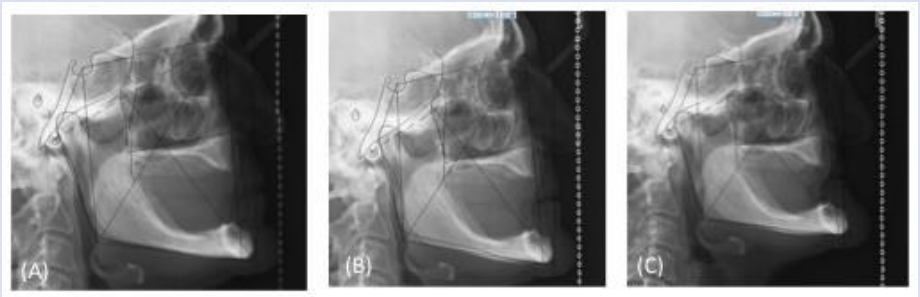

Figure 6: **A:** Lateral cephalogram taken with conventional technique; **B:** Lateral cephalogram taken with neutral zone technique; **C:** Lateral cephalogram of edentulous patient.

*Figure 7: **A:** Conventional technique superposed histogram; **B:** Neutral zone technique superposed histogram*

Table 1. Mean values of the soft tissue measurements for conventional technique (L1), neutral zone technique (L2), and edentulous (L3).

Measurement	1.Conventional (L1)	2.Neutral zone (L2)	3.Edentulous (L3)	Norm Value
Upper lip anterior to Sn Vertical (mm) (ULA-Sn Vertical)	5.4 mm	3.9 mm	0.5 mm	3 mm
Upper Lip-E (mm)	-8.2 mm	-11.1 mm	-15.3 mm	-6 mm
Upper lip protrusion (mm) (UL-SnPg')	1 mm	-0.7 mm	-4.1 mm	3 mm
Upper Lip Thickness to A point (mm)	14.7 mm	14.1 mm	10.2 mm	17mm
Lower lip anterior to Sn Vertical (mm) (LLA-Sn Vertical)	5.9 mm	4.6 mm	1.1 mm	1 mm
Lower Lip-E (mm)	-7 mm	-9.9 mm	-14.5 mm	-2 mm
Lower lip protrusion (mm) (LL-SnPg')	-0.2 mm	-1.9 mm	-5.2 mm	2mm
Upper lip length (mm) (Sn-Stms)	20.3 mm	22.6 mm	19.6 mm	21 mm
Lower Lip length (mm) (Stmi-Me')	40 mm	43.1 m	37.1 mm	40 mm
İnterlabial gap (mm)	1.5 mm	1.2 mm	1.1 mm	2 mm
Subnasale to Holdaway Line (mm)	1.5 mm	-1 mm	-5.8 mm	4.2 mm
Inferior sulcus to Holdaway Line (mm)	4.3 mm	4.7 mm	2.3 mm	4 mm
Superior sulcus depth (mm)	5.4 mm	3.5 mm	1.4 mm	3 mm
Chin Thickness (mm) (Pg-Pg')	12.5 mm	14.1 mm	13 mm	13.9 mm
Soft tissue pogonion to Sn Vertical (mm) (Pog'-Sn Vertical)	10.9 mm	12.9 mm	15 mm	-3 mm
Facial convexity (°) (G'-Sn-Po')	-4.5°	-5.9°	-16.8°	12°
Nasolabial angle (°)	97.1°	96.5°	104.9°	102°
H-Angle (Pg'UL-Pg' Na') (°)	-0.1°	-4.2°	-16.6°	10°
Sn-Stomion/Stomion-Me (%)	60.3	65.2	54.8	50
Soft tissue Face Height (G'-Sn:Sn-Me') (%)	1	0.9	1.1	1

Descriptons:

ULA: Upper Lip Anterior; **Sn**: Subnasale; **Sn Vertical**:Line Passing Through Subnasale And Perpendicular To The Horizontal Plane; **E:**E Line Passing Through Nasal Tip And Soft Tissue Pogonion; **UL**:Upper Lip; **SnPg'**:Line Passing Through Subnasale And Soft Tissue Pogonion; **A**:A Point; **LLA**:Lower Lip Anterior; **LL**:Lower Lip; **Sn-Stms**:Distance Between Subnasale And Stomion Superior; **Stmi-Me'**:Distance Between Stomion Inferior And Soft Tissue Menton; **Pg-Pg'**:Distance Between Hard Tissue Pogonion And Soft Tissue Pogonion; **Pog'-Sn Vertica**l: Distance Between Soft Tissue Pogonion And Sn-Vertical Line; **G'-Sn-Po'**:Angle Between Soft Tisue Glabella, Subnasale And Soft Tissue Pogonion; **Pg'UL-Pg' Na'**: Angle Between Line Passing Through Soft Tissue Pogonion And Upper Lip And Line Passing Through Soft Tissue Pogonion And Soft Tissue Nasion; **Me**: Menton; **G'Sn:Snme'**:Ratio Between Soft Tissue
Glabella- Subnasale and Subnasale-Menton Distances.

Table 2. 3dMD sofware volume comparison and surface differences.

Volume comparison and Surface Difference Measurements	Conventional (I1) superposed with no denture (I3)	Neutral zone (I2) superposed with no denture (I3)
Area Difference	2033.640 cm^2	2116.242 cm^2
Volumetric Difference	129.634 cc	63.969 cc
RMS (Min.-Max.)	2.61 (-53.17- 56.01)	2.44 (-24.30- 19.46)

RMS: Root Mean Square; **Min.:** Minimum; **Max.:** Maximum.

Discussion

The forces that are caused by soft tissues during mastication, speaking, and swallowing affects the stability of the dentures.[5] The denture stability is an important factor for the patients who have complete dentures, especially with inadequate tissue support and severe ridge resorption.[5,6] The neutral zone technique provides the maximum stability by determining the peripheral borders, tooth position, and external contours of the dentures.[6,8,9]

In the present case, the mandibular ridge of the patient was severely resorbed and she was carrying an uncomfortable conventional denture, which was fabricated a year ago. For this reason, it was decided to fabricate a new denture according to the neutral zone technique to increase patient satisfaction. However, the fabrication technique of the neutral zone dentures was different from conventional ones so somehow changes could be expected in the soft tissues of the patient's face. Therefore, in the present case, it was decided to evaluate the soft tissue changes that can be caused by two different fabricating dentures.

It has been reported that because of soft tissue loss and reduction of face height, horizontal and vertical lip contour changes could be observed in edentulous patients.[10] The cephalometric soft tissue measurements of the present case showed that upper and lower lips were positioned anteriorly in both conventional (L1) and neutral zone techniques (L2) on the sagittal plane. These results could be attributed to the fact that the placement of the prosthesis in the mouth helps direct lip position with big linear measurements. These results are in accordance with the other studies in the literature, in which a larger displacement of upper and lower lips after inserting a complete denture was encountered.[11,12] However from a clinical perspective, anterior positioning of the upper and lower lips was more pronounced in L1 than in L2. This result may be related to the fact that, the mandibular anterior teeth were placed more lingually in the neutral zone technique records, while the maxillary anterior teeth were placed closer to the position of the natural anterior teeth, as reported in a study.[13] Upper and lower lip lengths were found lower in L1 compared to L2 in the present case, which can be considered clinically significant. This result may be due to the fact that the tips of the lips were more deviated because of the positioning of the anterior teeth more anteriorly in the conventional technique. In accordance with the result of more pronounced upper anterior teeth proclination and upper lip protrusion, subnasale to H-Line measurement and superior sulcus depth measurements were also more pronounced in the conventional technique when compared to the neutral zone technique.

As the teeth in the dentures and the base of the prosthesis supported tissues around the mouth, facial convexity, and Holdaway angles increased in dentures fabricated with conventional (L1) and neutral (L2) techniques compared to edentulous (L3) cephalogram. This result is similar to the findings of Toyoshima *et al.*[14] and Pucciarelli *et al.*[15] Also, these convexity angle increases were more evident in L1 than in L2.

When comparing conventional and neutral zone techniques procedures with regard to the volumetric difference of superimposed images, the volumetric difference between conventional (I1) and no denture (I3) images was more pronounced compared to Neutral zone (I2) superposition with no denture (I3). This volumetric difference is an expected result that reflects all the differences in cephalometric soft tissue measurements between the two techniques discussed above.

During the control time of both conventional and neutral zone complete dentures, the patient's mastication, comfort, and speech were evaluated and compared. With the neutral zone denture, the patient could do these functions more comfortably, but with the conventional denture these functions, especially mastication, were limited. Also, there was seen major stomatitis that made the prosthesis uncomfortable with conventional technique. Stomatitis was seen over the crest of the lower ridge.

It has been reported that there are several factors affect denture stability such as flange contour and the influence of tooth position. When fabricating dentures, the polished surfaces and teeth positions may be determined according to the neutral zone. As the musculature will vary for every patient, dentists should not insist on placing the teeth over the crest of the ridge. Although the prosthesis made with the conventional technique showed superiority in terms of soft tissue changes in the present case report, it should be kept in mind that positioning artificial teeth in the neutral zone achieves more advantages.

Conclusions

An alternative mandibular denture impression technique, Neutral zone, has been suggested for the severely atrophic ridges. It has been recommended especially in edentulous cases where dental implants are not possible. It provides denture stability in muscular balance during function. Although the technique is simple, the chair time and laboratory costs increase. In the present case, although the dentures fabricated with the conventional technique provide superior esthetical soft tissue changes, especially in the upper and lower lip area, it should be keept in mind that the neutral zone denture provides better stability, retention, and normal muscle function.

Acknowledgement

This study has not been supported by any funding. The author declares that there is no conflict of interest. Written and informed consent had been taken from the patient for publication.

References

1. Porwal A, Jain P, Birader SP, Nelogi S, Naveen HC. Neutral zone approach for rehabilitation of severely atrophic ridge. Int J Dent Clin. 2010;2:53-57.
2. Glossary of prosthodontic terms. 7th ed. J Prosthet Dent. 1999;81-86.
3. Makzoume JE. Morphologic comparison of two neutral zone impression techniques: A pilot Study. J Prosthet Dent. 2004;92:563-568.
4. Raybin NH. The polished surface of complete dentures. J Prosthet Dent. 1963;13:236-239.
5. Patil PG. Conventional complete denture for a left segmental mandibulectomy patient: A clinical report. J Prosthodont Res. 2010;54:192-197.
6. Beresin VE, Schiesser FJ. The neutral zone in complete dentures. J Prosthet Dent. 1976;36:356-367.
7. Gibelli D, Pucciarelli V, Cappella A, Dolci C, Sforza C. Are portable stereophotogrammetric devices reliable in facial imaging? A validation study of VECTRA H1 device. J Oral Maxillofac Surg. 2018;76:1772-1784.
8. Gahan MJ, Walmsley AD. The neutral zone impression revisited. Br Dent J. 2005;198:269-272.
9. Fahmy FM, Kharat DU. A study of the importance of the neutral zone in complete dentures. J Prosthet Dent. 1990;64:459-462.
10. Ismail YH, George WA, Sassouni V, Scott RH. Cephalometric study of the changes occurring in the face height following prosthetic treatment. I. Gradual reduction of both occlusal and rest face heights. J Prosthet Dent. 1968;19:321-330.
11. Ushijima M, Kamashita Y, Nishi Y, Nagaoka E. Changes in lip forms on three-dimensional images with alteration of lip support and/or occlusal vertical dimension in complete denture wearers. J Prosthodont Res. 2013;57:113-121.
12. Fanibunda KB, Allcock GC, Thomason JM. Changes in the facial profile following insertion of complete dentures. Eur J Prosthodont Restor Dent. 2002;10:143-149.
13. Wright CR. Evaluation of the factors necessary to develop stability in mandibular dentures. J Prosthet Dent. 2004;92:509-518.
14. Toyoshima GHL, Pucciarelli MGR, Neppelenbroek KH, Sforza C, Menezes M, Oliveira TM, et al. Evaluation by 3D stereophotogrammetry of facial changes in edentulous patients after rehabilitation. J Appl Oral Sci. 2021;30:e20210462.
15. Pucciarelli MGR, Hideki de Lima Toyoshima G, de Oliveira TM, Neppelenbroek KH, Soares S. Quantifying the facial proportions in edentulous individuals before and after rehabilitation with complete dentures compared with dentate individuals: A 3D stereophotogrammetry study. J Prosthet Dent. 2022 Apr 14:S0022-3913(22)00188-3.