A Stereophotogrammetry Face Study Between Dentate and Edentulous Adults Rehabilitated with Either a Conventional Complete or an Implant-Supported Fixed Complete Denture

Keywords

Photogrammetry
Human
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ABSTRACT

Quantifying in edentulous patients the facial collapse and whether complete conventional denture (CCD) and implant-supported fixed complete denture (ISFCD) can restore the facial proportions to match those of a dentate patient (CG) is relevant for clinical dentists. One hundred and four participants were enrolled and divided into edentulous (n=56) and CG (n=48). The edentulous participants were rehabilitated with CCD (n=28) or ISFCD (n=28) in both arches. Anthropometric landmarks in the face were marked and captured by stereophotogrammetry. Linear, angular, and surface measurements were analyzed and compared among groups. The statistical analysis was performed by an independent t-test, the one-way ANOVA, and Tukey's test. The significance level was set at 0.05. The facial collapse was quantified as a significant shortening of the lower third of the face affecting facial aesthetics in all parameters evaluated and the same was observed in comparison among CCD, ISFCD, and CG. The CCD presented statistical differences with the CG group in the lower third of the face and labial surface, and the ISFCD showed no statistical differences with the CG and CCD. The facial collapse in edentulous patients could be restored through oral rehabilitation with an ISFCD similar to those of dentate patients.

INTRODUCTION

Stereophotogrammetry technology is used by the scientific community to study the soft tissue of the face[1,2] and to evaluate linear, angular, surface and volume measurements.[3-5] The method is reliable[3,4] and accurate and surpasses two-dimensional (2D) photography.[5] The noncontact 3D surface capture method is a noninvasive technique that offers advantages including direct measurements.[6] Facial proportion measurements are essential for the clinician when the planned treatment involves tooth and facial soft tissue changes, such as with orthodontics,[7] plastic surgery,[8] and complete mouth rehabilitation.[9-11]

Oral rehabilitation with complete dentures has been widely studied and the rate of the edentulous population in developing countries is expected to grow.[12] Edentulism is still considered a public health problem by the World Health Organization.[13,14] The etiology of edentulism involves microbial or genetic diseases and iatrogenic, traumatic, or therapeutic causes.[15,16] Edentulous patients experience difficulties with chewing and speech, and also with poor facial aesthetics.[10,16,17] Edentulism is associated with facial collapse, leading to shortening in the lower third of the face, deep wrinkles, and visible drooping of the related labial commissures.[9,18] Loss of function and aesthetics problems are also associated with a poor quality of life in these patients.[10,17]

Prosthetic treatment with different types of complete denture, a conventional complete denture (CCD) or implant-supported fixed complete denture (ISFCD), can restore masticatory function with artificial teeth and help maintain a natural facial appearance. The lower third of the face has a notable impact on the facial appearance. For complete denture wearers to retain a natural appearance,[19,20] adequate lip support and an appropriate occlusal vertical dimension (OVD) must be provided.[21] These are the aims of these two types of prostheses, even though they have different indications and characteristics in terms of mechanical retention, the amount of acrylic resin material and the occlusal scheme.[10]

Lip support with complete dentures has been evaluated[21-24] but CCDs have a labial flange that is absent with ISFCDs.[22] The flange is defined as the portion of a complete denture that occupies the buccal surface[25] but has been reported to provide only minimal and clinically insignificant differences in lip support.[23]

Studies that measured changes in facial proportions after oral rehabilitation with complete dentures are sparse,[20] although facial changes before and after oral rehabilitation with CCDs[9,11] and ISFCDs[24] have been measured with stereophotogrammetry. However, the authors are unaware of a study comparing how different prostheses affect facial aesthetics and that quantifies facial collapse based on a control group (CG).

The present research aimed to quantify facial collapse caused by tooth loss compared with a dentate patient (CG) and to quantify whether two different types of complete dentures (CCD and ISFCD) can restore facial proportions similar those of the CG by stereophotogrammetry. Rehabilitating an edentulous patient is challenging because the professional performs a mix of technics to restore the lower third of the face, and the parameters are subjective and based on dentate patients. However, are these values the same in rehabilitating patients? Based on this question, the null hypothesis tested was that the facial measures in patients rehabilitated with complete dentures, conventional or implant-supported fixed, did not show differences from dentate individuals.

MATERIAL AND METHODS

SAMPLE SELECTION

This cross-sectional study was conducted after approval by the institutional review board. Written informed consent was obtained from all participants under protocol number CAAE: 99721718.6.0000.5417. The sample was composed of 104 individuals, edentulous patients (mean age 62.23±7.15 years), and dentate patients (mean age 60.06±4.95 years). The edentulous group (n=56/19 male and 37 female) was analyzed under two different clinical conditions and compared with the CG (n=48/26 male and 22 female). The initial clinical situation was before oral rehabilitation, and the final clinical condition was after the delivery of complete dentures in both arches: a conventional complete denture, the CCD group (n=28), and the implant-supported fixed complete denture, the ISFCD group (n=28) (*Figure 1*).

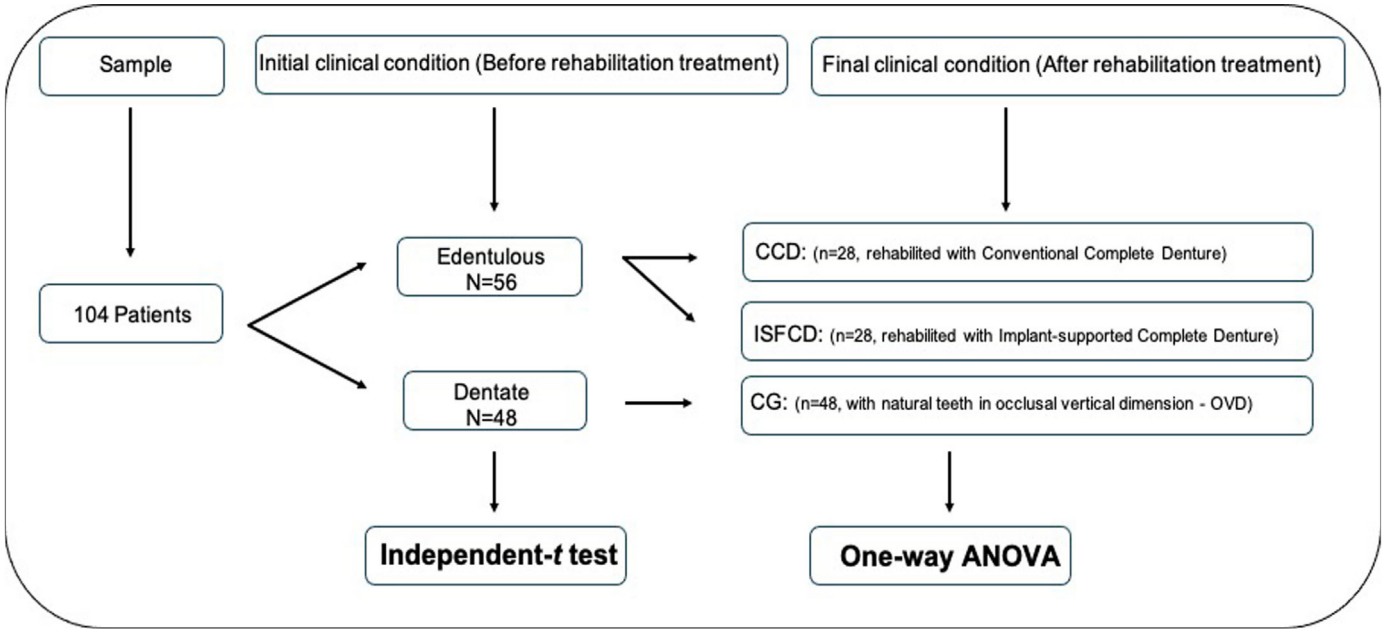

Figure 1: Flow chart of the sample and statistical analysis

The sample size calculation was based on a pilot study according to the t-test adopted in the present study. Ten patients were evaluated previously, and considering a minimum relevant difference of at least 2.3 mm in the alteration of the soft tissues (standard deviation, 2.97 mm), adopting a significance of 0.05 and test power of 0.80, the sample size obtained was at minimum 28 participants.[11] The inclusion criteria for the edentulous group were that they had been edentulous at least five and no more than 15 years; indication of CCD and ISFCD in both arches *(Figure 2)*, fabricated between 2020 and 2022, by one prosthodontist (S.S.), and one dental laboratory technician. During the establishment of OVD in the CCD and ISFCD groups, the relationship was determined based on the Willis method.[26] To determine the nasolabial angle, it was established as an obtuse angle >90° as a prosthodontic guideline.[27] The ISFCD group was composed of patients with clinical and systemic conditions able to receive implants. The ISFCD group received six and four implants in the maxilla and mandible, respectively. The inclusion criteria for the CG group were individuals with an OVD maintained by natural teeth without removable prostheses, Angle class I, no bruxism, and no laminate veneer or other prostheses in anterior teeth. The exclusion criteria for both groups were all kinds of aesthetic procedures on the face, compromised neuromuscular health, and the presence of a mustache, beard, or facial hair (mainly in men). The CG group was evaluated and compared with the other two groups because the parameters observed in the CG group and their values are relevant to be established and followed.

IMAGE ACQUISITION

The facial analysis was performed through 3D stereophotogrammetry with the VECTRA H1 device (Canfield Scientific Inc, Fairfield, NJ, USA) after 3 to 6 months that patients received CCD or ISFCD. A sequence of 21 anthropometric landmarks[28] was marked on the face with an eyeliner by two previously calibrated examiners (analog landmarks) (MGRP and GHLT) *(Table 1)*. Anthropometric landmarks such as ExR/L and ChR/L (digital landmarks) were pointed directly in the program because they are the easiest to point.

The CCD and ISFCD groups underwent 3D facial analysis twice on the same day, the first time with the dentures in place and the second without. The CG group was examined only once by stereophotogrammetry. The analysis was performed by using the Vectra Analysis Module software (VAM elaboration, Canfield Scientific Inc., Fairfield, NJ, USA) through linear, angular, surface, perimeter and volume measurements *(Table 1)*.

The analysis of the superimposition of 3D images was performed to show the changes in the facial contours of the edentulous group after rehabilitation. The volume was performed by calculating the root mean square (RMS) between images before and after the delivery of rehabilitation. This calculation at first aligns similar areas and landmarks for the two conditions (for instance, the forehead or the frontotemporal landmarks may be used for treatments that do not act altering on the upper part of the face) and then mathematically superimposes the first with the second image (after and before). The distances between the homologous regions of the faces are calculated for each geometrical element of the mesh. The values are squared considering all planes of the face, and an overall mean distance is provided.[4] The root-mean square (RMS) equal to 0.20 was considered accurate,[4] and the matched areas were through the non-changed, as the forehead, surrounded by the points (TR – G – TL - Tr). A chromatogram map was generated, representing unchanged areas (in green) and decreased (in red) and increased (in blue) facial volumes *(Figure 3)*.

The kappa coefficient was applied to check the agreement between the operators who made the anthropometric landmarks on the face (0.81 for the analog landmarks and 0.84 for the digital landmarks). The operators saved the landmarks on the system after calibration. Only the MGRP operator performed the quantitative analysis based on the anthropometric landmarks defined and previously saved.

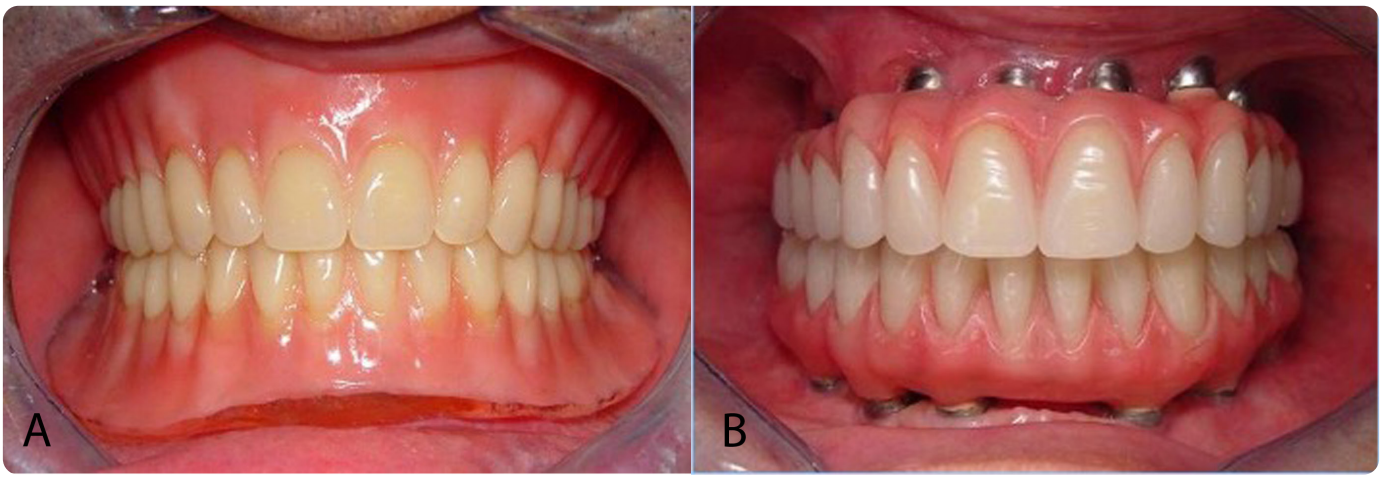

Figure 2: A) Conventional complete denture (CCD). B) Implant-supported fixed complete denture (ISFCD).

Table 1. List of abbreviations and definitions of the measurements.

Linear Measures	Definition
Tr – G	Upper third of the face;
G – Sn	Middle third of the face;
Sn – Gn	Lower third of the face;
N – Pg	Distance between nasion and pogonion;
Sn - Pg	Lower facial height;
Ls - Li	Height of the upper and lower vermilion;
Sn - Ls	Height of the cutaneous upper lip;
Ex (R) - Ch (R')	Distance between exocanthion and cheilion' (right);
Ex (L) - Ch (L')	Distance between exocanthion and cheilion' (left);
Ac (R) – Ac (L) Al (R) – Al (L) ChR- ChL	The width between the alar curvature; Nasal width; Labial fissure width;
CphR - CphL	Width of the philtrum;
Angular Measures	**Definition**
Prn-Sn-Ls Ls-St-Li Sn-St-Pg T(R) – Prn – T(L) T(R) – Pg – T(L) Go(R) – Pg - Go(L) N–Sn–Pg T(R)-Go(R)-Pg T(L)-Go(L)-Pg	Nasolabial angle; Sealed lips angle; Lower facial convexity; Middle facial convexity; Lower facial convexity; Mandibular convexity; Facial convexity (excluding nose); Right gonial angle; Left gonial angle;
3D Measures	
Ac(L)-T(L)-Go(L)-Gn-Go(R)-T(R)-Ac(R)	Surface of the lower third of the face
Ac(L)-T(L)-Go(L)-Gn-Go(R)-T(R)-Ac(R)	Perimeter of the lower third of the face
Ac(L)-T(L)-Go(L)-Gn-Go(R)-T(R)-Ac(R)	Volume of the lower third of the face

STATISTICAL ANALYSIS

The Kolmogorov-Smirnov test was used to test the normality of the data (p>0.05). The independent t test was used to compare the initial clinical condition of the edentulous group with the CG group, the one-way ANOVA and Tukey test to compare the groups after oral rehabilitation. All statistical analyses were performed with open-source software Jamovi v.1.2 (The Jamovi project, Sydney, Australia) with a significance level of 0.05 and a test power of 0.80.

RESULTS

One hundred and four edentulous (CCD and ISFCD, mean age 62.23±7.15 years), and dentate (CG, mean age 60.06±4.95 years) individuals were evaluated with no statistical differences between ages (p = 0.07). The edentulous group (CCD and ISFCD, n=56/19 male and 37 female) was compared with the CG (n=48/26 male and 22 female) *(Table 2)* and the rehabilitation with CCD, ISFCD, and CG was compared among them *(Table 3)* *(Figure 1)*.

Table 2 quantified the facial collapse in the edentulous participants. The analysis was based on edentulous and dentate participants, and the results showed statistically significant differences in eight linear measurements, five angular measurements and the surface and perimeter.

The comparisons among the prosthesis types (CCD and ISFCD) and the CG showed statistically significant differences in six linear and four angular measurements and the surface and perimeter *(Table 3)*.

DISCUSSION

Changes in the face are notable after oral rehabilitation with complete dentures that can be quantified precisely with stereophotogrammetry technology.[9,11,21,24,29] Facial proportions are evaluated before and after the treatment to understand how the prostheses impacted facial aesthetics.[9,11] Clinicians should model rehabilitation on a dentate patient to achieve similar measures.

One hundred and four individuals were compared to verify facial measurements between the CG and edentulous group and among CCD and ISFCD rehabilitation and the CG. The present study is novel in that it compared these two kinds of rehabilitation with a CG. The null hypothesis was partially rejected. The comparison between the edentulous group and the CG presented differences in linear, angular, surface and perimeter measures. Comparing patients rehabilitated with CCD and ISFCD and the CG, the differences were observed mainly between the CCD group and CG, while between the ISFCD group and CG, only the TR-GoR-Pg measure showed a statistically significant difference.

FACIAL COLLAPSE AND OVD

Previous studies have quantified facial collapse by analyzing edentulous facial proportions,[9,11,21] and a shortening in the lower third of the face has been observed[18] in edentulous patients. The linear measures assessed in the present study documented how the collapse was represented in the total face evaluation, as the present study compared edentulous patients and the CG of dentate people matched by age.

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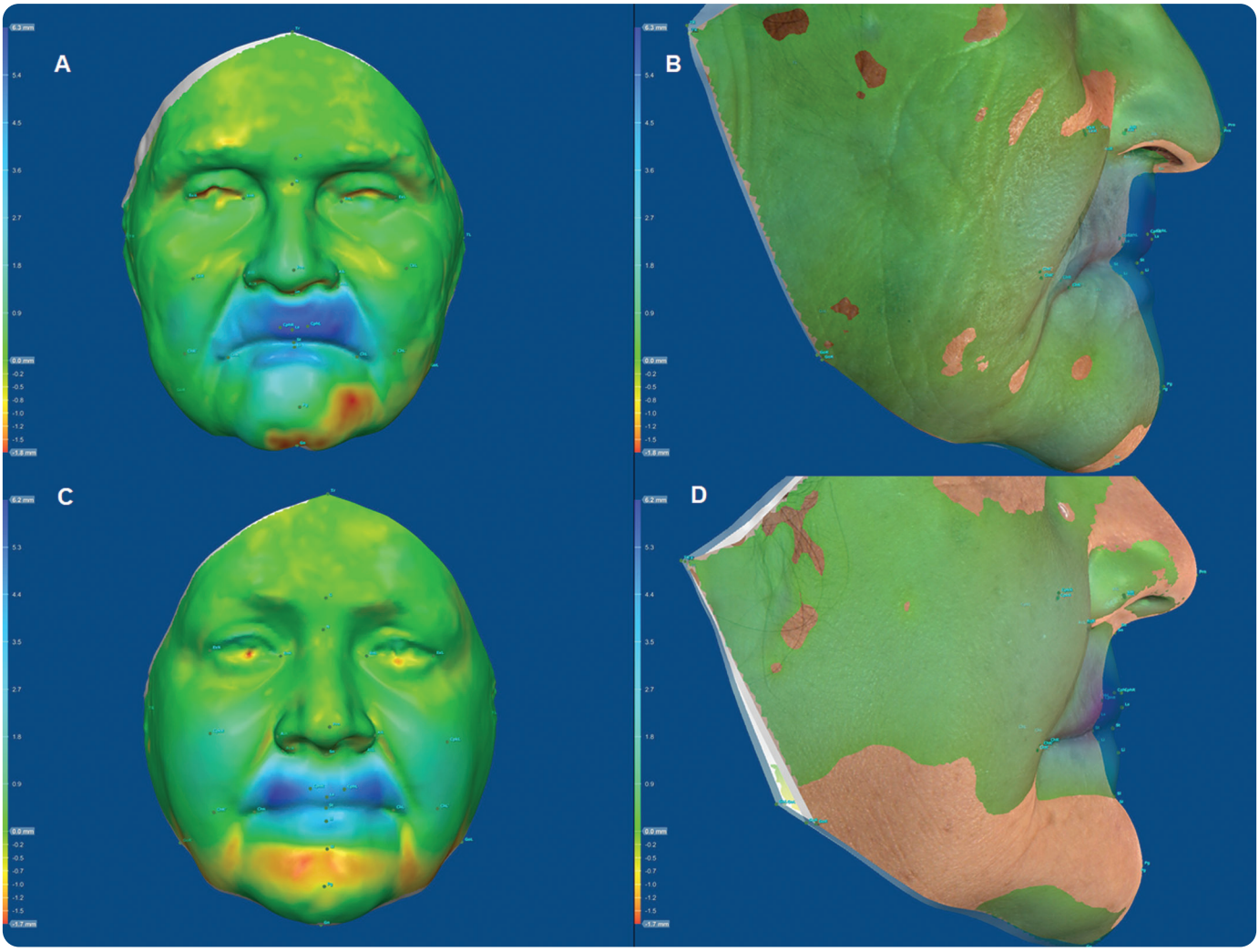

Figure 3: A) Facial analysis with different colors of the superimposition with and without conventional complete denture (CCD) in frontal view (green, superimposed areas; red and blue, discordant areas between the 2 scans). B) Superimposition of the changes in the lower third of the face with and without complete denture (green, superimposed areas; red and blue, discordant areas between the 2 scans) C) Facial analysis with different colors of the superimposition with and without implant-supported fixed complete denture (ISFCD) in frontal view (green, superimposed areas; red and blue, discordant areas between the 2 scans) D- Superimposition of the changes in the lower third of the face with and without implant-supported fixed complete denture (green, superimposed areas; red and blue, discordant areas between the 2 scans).

The edentulous patients presented diminished OVD (Sn-Gn, p=0.02) compared with the CG. Consistent with previous studies,[9,11,24] the change in OVD can significantly affect the lower third of the face (N-Pg, p=0.03; Sn-Pg, p=0.009). Oral rehabilitation with CCD and ISFCD restored the facial proportions, increasing these measurements similar to CG, with no statistical differences between prostheses and the CG (Sn-Gn/Sn-Pg: CCD/CG; N=Pg: ISFCD/CG), and, as observed in the Tartaglia *et al*. study, an increase in the Sn-Pg measure.[24]

ORAL REHABILITATION TO RESTORE FACIAL PROPORTIONS

Before oral rehabilitation, the edentulous group differed by eight linear measurements from the CG (Sn-Gn, N-Pg, Sn-Pg, Ls-Li, ExR-Ch'R, ExL-Ch'L, ChR-ChL, CphR-CphL) *(Table 2*), these differences were reduced to three after delivery of the complete dentures. The measurement differences were mainly between the CCD group and the CG: N- Pg, Ex-Ch' both on the right and left sides *(Table 3*). The CCD group still presented the lowest values. These results suggest that oral rehabilitation with CCD or ISFCD can improve the facial profile as reported in previous studies.[21,22,24] However, treatment with ISFCDs provided similar facial metrics to dentate individuals, as no statistical differences with the CG were found in linear, surface and perimeter measurements. Only in one angular measurement (TR-GoR-Pg), was a statistically significant difference observed between ISFCD and CG.

The ISFCD group mean values were higher than those of the CG in the linear measures, with statistically significant differences except in ExR-Ch'R and ExL-Ch'L. The higher measurements may be explained by the framework in the implant-supported fixed complete denture, and this influence requires further research.

Table 2. Comparison of linear, angular and lower third of the face measurements between the edentulous group (n=56) and the control group (n=48).

Linear measures (13)	Edentulous Group (n=56) Mean±SD	CG (n=48) Mean±SD	p ≤ 0.05
Tr-G	52.9±9.70	55,9±10.57	0.10
G-Sn	62.51±4.73	63.16±5	0.50
Sn-Gn	66.00±5.80	68.75±6.08	0.02*
N-Pg	103.50±8.22	106.93±7.90	0.03*
Sn-Pg	52.72±5.39	55.7±6.07	0.009*
Ls-Li	7.81±2.86	11.3±2.99	<.001*
Sn-Ls	18.02±3.02	18.5±3.11	0.402
ExR-Ch'R	65.7±4.58	69.2±5.48	<.001*
ExL-Ch'L	65.6±4.75	69.1±5.3	<.001*
ChR-ChL	46.3±6.51	51.6±5.07	<.001*
CphR-CphL	11.34±1.82	12.3±2.11	0.014*
AcR-AcL	35.46±3.49	35±3.52	0.55
AlR-AlL	35.57±3.79	35.9±3.89	0.70
Angular Measures (9)	**Edentulous Group (n=56) Mean±SD**	**CG (n=48) Mean±SD**	**p ≤ 0.05**
Prn-Sn-Ls	131.66±12.14	121.4±8.84	<.001*
Ls-St-Li	130.11±17.93	134.2±14.91	0.21
Sn-St-Pg	157.85±13.04	170.4±5.66	<.001*
TR-Prn-TL	66.13±2.72	64.7±2.53	0.005*
TR-Pg-TL	63.19±2.32	62.2±2.87	0.06
GoR-Pg-GoL	77.83±4.91	75.4±5.11	0.017*
N-Sn-Pg	171.21±6.86	167.6±5.71	0.005*
TR-GoR-Pg	126.78±5.07	125.3±4.97	0.14
TL-GoL-Pg	124.04±6.65	122.2±6.12	0.15
Lower Third of the Face	**Edentulous Group (n=56) Mean±SD**	**CG (n=48) Mean±SD**	**p ≤ 0.05**
Surface	164.4±20.56	178.1±22.33	0.002*
Perimeter	603.5±34.51	619.2±39.14	0.032*

SD - standard deviation/ independent *t* test/ * statistically significant difference (p < 0.05)

Table 3. Comparison of linear, angular and lower third of the face measurements among edentulous group rehabilitated with conventional complete denture (CCD) (n=28), rehabilitated with implant-supported fixed complete denture (ISFCD) (n=28), and the control group (n=48).

Linear measures (13)	CCD (n=28) Mean±SD	ISFCD (n=28) Mean±SD	CG (n=48) Mean±SD	*F*	*P*
Tr-G	53.1±8.4[a]	51.2±10.16[a]	55.9±10.57[a]	1.91	0.15
G-Sn	61.3±5.09[a]	63.4±4.42[a]	63.2±5[a]	1.65	0.2
Sn-Gn	66.2±4.95[a]	71.4±5.37[b]	68.8±6.08[ab]	7.07	0.002*
N-Pg	102.4±7.44[a]	108.8±5.77[b]	106.9±7.9[b]	6.32	0.003*
Sn-Pg	53.4±5.48[a]	57.2±4.8[b]	55.7±6.07[ab]	3.81	0.02*
Ls-Li	10.8±2.51[a]	12.7±2.86[b]	11.3±2.99[ab]	3.70	0.03*
Sn-Ls	16.8±3.3[a]	18.3±2.39[a]	18.5±3.11[a]	2.50	0.09
ExR-Ch'R	65.4±5.06[a]	67.6±3.77[ab]	69.2±5.48[b]	4.73	0.01*
ExL-Ch'L	65.4±5.62[a]	67.8±3.97[ab]	69.1±5.3[b]	4.14	0.02*
ChR-ChL	50.8±4.62[a]	53.4±5.91[a]	51.6±5.07[a]	1.65	0.2
CphR-CphL	11.8±1.74[a]	12.9±1.81[a]	12.3±2.11[a]	2.80	0.06
AcR-AcL	36.7±3.44[a]	35±3.47[a]	35±3.52[a]	2.36	0.10
AlR-AlL	34.9±3.42[a]	36.7±4.29[a]	35.9±3.89[a]	1.58	0.21
Angular Measures (9)					
Prn-Sn-Ls	124.2±11.56[a]	120.4±10.8[a]	121.4±8.84[a]	0.88	0.42
Ls-St-Li	124.4±16.91[a]	130.9±11.51[ab]	134.2±14.91[b]	3.23	0.04*
Sn-St-Pg	168.7±7.65[a]	166.8±6.48[a]	170.4±5.66[a]	2.99	0.05*
TR-Prn-TL	66.3±3.78[a]	65.97±1.96[ab]	64.7±2.53[b]	4	0.02*
TR-Pg-TL	63.3±2.06[a]	62.8±2.29[a]	62.2±2.87[a]	1.69	0.19
GoR-Pg-GoL	76.8±4.77[a]	79.5±4.75[ab]	75.4±5.11[b]	5.92	0.004*
N-Sn-Pg	168±8.15[a]	169.4±5.61[a]	167.6±5.71[a]	0.82	0.44
TR-GoR-Pg	127.1±5.32[ab]	128.4±5.1[a]	125.3±4.97[b]	3.34	0.04*
TL-GoL-Pg	125.6±5.92[a]	126±23.03[a]	122.2±6.12[a]	3.38	0.07
Lower Third of the Face					
Surface	162.1±16.01[a]	171.1±23.03[ab]	178.1±22.33[b]	6.538	0.003*
Perimeter	593.7±26.79[a]	614±37.51[ab]	619.2±39.14[b]	6.205	0.004*

SD - standard deviation/ One-way ANOVA/ * statistically significant difference ($p < 0.05$). Means followed by different letters in line differ statistically by Tukey test (5%)

The nasolabial angle and the labial protrusion are influenced by the position of the anterior dentition.[20,21,30] The present investigation corroborated Bidra *et al*.[23] study that flanged (CCD) and flangeless (ISFCD) prostheses were equally viable as they did not differ statistically from each other nor from the CG in terms of the nasolabial angle (Prn-Sn-Ls). This result suggests that clinicians could provide either type of prostheses (CCD and ISFCD) in the maxillary arch based on the evaluation of labial support.

The surface and perimeter presented differences in dentate and edentulous patients, with higher values in dentate patients. When evaluating the types of rehabilitation (CCD and ISFCD), the ISFCD presented results similar to dentate patients.

Limitations of the present investigation included the cross-sectional study design, the measurements made for only one ethnic group, Caucasian individuals, and the small sample size. Including as limitations, we did not evaluate the residual ridge and established at least five and no more than 15 years to edentulous patients. The study was developed in three different groups, and it would be better if we compare CG with one group that received a CCD and later an ISFCD.

CONCLUSION

Facial collapse occurs in the lower third of the face in edentulous patients compared with dentate patients. Rehabilitating patients with implant-supported fixed complete dentures can restore facial proportions similar to those of dentate patients.

CLINICAL IMPLICATIONS

Understanding the facial metrics in dentate and rehabilitated patients is relevant for clinical dentists because it can help to establish new parameters, mainly if these values are accurate and reliable based on 3D stereophotogrammetry.

DECLARATIONS

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CONFLICTS OF INTEREST

The authors declare no competing interests.

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