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Three dimensional assessment of soft tissue facial changes following premolars extraction using laser scanner

A prospective Clinical Trial

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Title

Three dimensional assessment of soft tissue facial changes following premolars extraction using laser scanner

Abstract

This study was conducted on 13 female patients aged from18 to 40 years, selected from the outpatient clinic of the orthodontic department at the Faculty of Dentistry, Ain Shams University. They were selected based on specific inclusion criteria.

The aim of the study was to evaluate the effect of extracting upper premolars and retracting the anterior segment on soft tissue in three dimensions using the Planmeca Proface laser scanner.

In our study, we wanted to evaluate the soft tissue facial changes, so we used a 3D diagnostic aid in order to prevent any errors that could occur with 2D diagnostic tools that were previously used by many researchers.

After leveling and alignment, extraction was performed to the premolars to initiate retraction of the anterior segment.

Three-dimensional images of the patients were acquired using the Planmeca Romexis software laser scanner Proface immediately after extraction (prior to starting retraction) and after the retraction of anterior teeth completed.

These images were later used for several measurements on facial soft tissue showed clinically significant changes mainly in anteroposterior dimensions.

Objective

To evaluate the effect of extracting upper premolars and retracting the anterior segment on soft tissue in three dimensions using the Planmeca Proface laser scanner .

Materials and methods

This study was conducted on 13 female patients with age ranging from 18 to 30 years.Orthodontic records were taken for patients who meet the inclusion criteria. These records included diagnostic Procedures as case history, clinical examination, radiographs including panoramic radiographs, and lateral cephalometric radiographs, study models, photographs(Extra-oral and intra-oral) and 3D Proface measurements were taken directly after extraction (before starting retraction) and after retraction of anterior teeth was completed .These images were later used for several measures on facial soft tissue .Measurements obtained pre-retraction were compared to those of post retraction to determine

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the effect of retraction on facial soft tissue.

Results

The results showed that there was a significant difference in all measurements especially anteroposterior one (P value < 0.05) leads to enhancement of the facial profile this was due to retraction of lips that follow the retraction of teeth.

Conclusion

Planmeca promax proface reproducing the texture and color of soft tissue, reconstructing 3D images immediately on related software determining that the upper and lower lips retracted by a noticeable amount that leads to an increase in their lengths, Also a noticeable changes occurred to the profile of the patients.

Introduction

Both soft and hard tissues of the craniofacial are very important for orthodontic diagnosis and treatment planning. Conventionally orthodontists gave greater attention to hard tissue than soft tissue but nowadays all orthodontists admit that success in their treatment is related to favorable changes in soft tissue [1-3].

Therefore, the actual appearance of a patient's face is the most important issue in orthodontics and facial esthetics. It has become the ultimate goal of orthodontic treatment to which all treatment procedures are directed. Hence, improving soft tissue esthetics has become the main target of orthodontists.

One of the major chief complaints of patients seeking orthodontic treatment is bimaxillary dento-alveolar protrusion which requires premolars extraction and anterior segment retraction to be corrected. It characterized by protrusion of both maxillary and mandibular incisors and increased lip prominence. It is verified that retraction of the anterior teeth in these cases will be followed by changes in the soft tissue profile, such as a decrease in soft tissue facial convexity [4-6].

Several studies [7-10].Discussed the extraction and retraction effect of the anterior segment on both upper and lower lips, but they did not tackle their effect on soft tissue over all the face by a 3D technique. The facial soft tissue changes have long been assessed by using conventional two-dimensional (2D) analysis techniques, but they have a lot of limitations in analyzing the full soft tissue changes [11].

Two-dimensional analysis reduces a three-dimensional object to a two dimensional one by projecting all structures onto a single plate, thereby creating difficulties when it comes to understanding the changes and under taking a comprehensive analysis. This is specially noted in the transverse dimension and mid-face area which cannot be detected by the 2D assessment.

Recently, many techniques for 3D soft-tissue analysis have been developed, such as stereophotogrammetry, 3Dcomputed tomography, 3D laser scanning, structured light technique and moiré topography [12]. These methods help in collecting the three-dimensional data that aids in diagnosis, treatment planning and evaluation of treatment. They use optical non-contact instruments such as laser scanners, three-dimensional range cameras and stereophotogrammetry. Among these

methods we find 3D laser scanning, which has a lot of advantages as sparing the risk of ionizing radiation to the patient, using a non-hazardous laser, reproducing the texture and color of soft tissue, reconstructing 3D images immediately on related software. This method has a short acquisition time and it is suitable for daily analysis and evaluation of soft tissue [13,14].

In our study we will quantify the changes in the facial soft tissue after premolars extraction and anterior segment retraction to evaluate the esthetic results of these changes, using the 3D laser scanner Promax 3D Mid Proface with Romexis software [15,16].

Aim of the study

The aim of the study was to evaluate the effect of extracting upper premolars and retracting the anterior segment on soft tissue in three dimensions using the Planmeca Proface laser scanner.

Materials and methods

The ethics committee at the Faculty of Dentistry Ain-Shams University approved the study design after reviewing the study protocol.

This study was part of a Master's degree in Orthodontics at the Faculty of Dentistry, Ain-Shams University. No financial conflicts of interest were declared. The study was self-funded by the principal investigator.

This study was conducted on 13 female patients with age ranging from

18 to 30 years, selected from the outpatient clinic of the orthodontic department, Faculty of Dentistry, Ain- Shams University.

Study procedures

The subjects were selected according to the following:.

1. Inclusion criteria:

a. Patients aged between 18 and 40 years.

b. Cases seeking extraction of upper premolars and anterior segment retraction.

c. Full permanent dentition, with no missing teeth except for the third molars.

2. Exclusion criteria:

a. Medical problems that affect tooth movement (e.g.,osteoporosis, bisphosphonate therapy, etc).

b. Past or present orthognathic surgery.

C. Pathological and developmental anomalies that affect the oro-facial region.

D. Cleft lip and palate patients.

e. Facial asymmetry or craniofacial disorders.

f. Previous or current orthodontic treatment.

Sample Size Calculation:

A power analysis was designed to have adequate power to apply a two sided statistical test of the research hypothesis (null hypothesis) that there is no difference between the tested groups. By adopting an alpa (α) level of 0.05(5%),abeta (β) level of 0.80 (80%) (i.e.power=80%) , and an effect size (d) of (1.5) calculated based on the results of a previous study[4]; the predicted sample size (n) was a total of (13) cases. Sample size calculation was performed using Power (Fig 1).

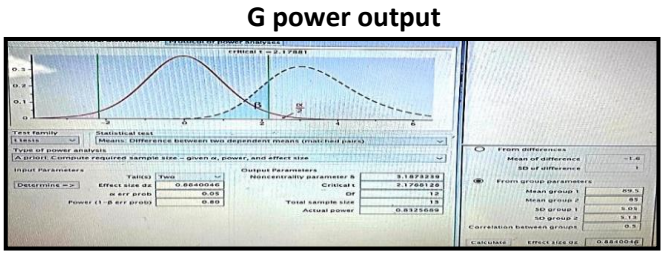

Figure 1: sample size calculation

1. Participants who agreed to participate were given a full detailed explanation of the study before any procedure.
2. An informed consent was signed by the participants before their enrollment in the study in which the aim of the study and the methodology were clearly described.
3. After leveling and alignment, extraction was performed to the premolars to initiate retraction of the anterior segment.
4. Three-dimensional images of the patients were acquired using the Planmeca Romexis software laser scanner Proface immediately after extraction (prior to starting retraction) and after the retraction of anterior teeth completed.
5. This device is a laser scanner used to generate a standardized 3D photo of the face.
6. Before initiating any procedure, the necessary points were marked clinically on patient's face by the operator before scanning for better localization of the points in the 3D program (Fig 2).

Figure 2: Facial landmarks marked clinically.

7. Then the patient stands with their head in a natural position while cephalostat is fixing the head (Fig 3).
8. Digitization was done by a single operator.
9. The technical expert took all scans, and each image saved on a personal computer, then merged them into a single 3D facial image using Romexis® software .These images were later used for several measures on facial soft tissue.(Fig 4)
10. Points added on the 3D program were superimposed on the previously added points clinically,then any point-to-point measurement could be obtained from those localized landmarks on the 3D photos by the Romexis® software.
11. Measurements obtained pre-retraction were compared to those of post retraction to determine the effect of retraction on facial soft tissue.

Figure 3: The patient stands

Figure 4: 3D photos by romexis software with their head in a natural position.

Statistical analysis

Statistical analysis was performed with SPSS 20®1, Graph Pad Prism®1, and Microsoft Excel 20163. Qualitative data were explored for normality by using Shapiro Wilk and Kolmogorov Normality test and presented as minimum, maximum, means and standard deviation (SD) values. All data were presented in tables & graphs.

Tests used:

- **Shapiro Wilk and Kolmogorov Normality test for normality exploration.**

- **Paired t test to compare between pre and post measurements.**

ICC (inter-class correlation coefficient) to evaluate intra-observer and inter-observer reliability.

Results

- Inter observer reliability and intra-observer reliability was performed by using ICC (interclass correlation coefficient**).**

A. Intra-observer reliability:

Intra-observer reliability was used to evaluate the agreement between 2 readings of the same observer and revealed excellent agreement (α = >0.9) in all measurements.

B. Interobserver reliability:

Interobserver reliability was used to evaluate the agreement between 2 observers and revealed excellent agreement (α = >0.9) in all measurements.

I. Normality test:

Exploration of the given data was performed using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality, it was revealed that the significant level(P-value)was shown to be insignificant as P-value > 0.05, which indicated that data originated from normal distribution (parametric data) in all classes regarding all measurements.

Antero-posterior measurements.

Table 1 represents the pre and post anteroposterior linear measurements. It revealed that there was a significant change in all measurements with P value < 0.05

Table (1): Minimum, maximum, mean, and standard deviation of pre and post anteroposterior linear measurements and comparison between them using Paired t test:

Linear Measurements (Antero-Posterior)		Minimum	Maximum	Mean	Standard Deviation	Paired Differences					P value
						Mean	Standard Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
									Lower	Upper	
sn-tm	Pre	98.70	116.90	112.62	6.41	-6.62	1.38	0.38	-7.45	-5.79	0.0001*
	Post	91.15	110.00	106.00	6.70						
ls (prn-pg)	Pre	2.00	6.00	4.33	1.49	-4.67	2.13	0.59	-5.96	-3.38	0.0001*
	Post	-2.00	1.00	-.33	1.11						
li-(prn-pg)	Pre	1.00	7.00	3.50	1.98	-3.50	0.96	0.27	-4.08	-2.92	0.0001*
	Post	-4.00	3.00	0.00	2.24						
Ss to E line	Pre	3.00	11.90	8.73	3.03	-4.07	0.82	0.23	-4.56	-3.57	0.0001*
	Post	0.00	7.00	4.67	2.43						
Si to E line	Pre	0.00	7.50	3.75	2.67	-2.75	0.69	0.19	-3.17	-2.33	0.0001*
	Post	-2.00	5.00	1.00	2.58						

*Significant difference as P<0.*05*

Vertical measurements

Table 2 represents the pre and post vertical measurements. The difference between pre- and post-treatment measurements and comparison between them was performed by using Paired t test which revealed that:

There was a significant change in all measurements with P value < 0.05.

Table (2): Minimum, maximum, mean, and standard deviation of pre and post vertical linear measurements and comparison between them using Paired t test:

Linear Measurements (Vertical)		Minimum	Maximum	Mean	Standard Deviation	Paired Differences					P value
						Mean	Standard Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
									Lower	Upper	
sn-pg	Pre	47.80	62.00	52.95	4.52	0.62	0.38	0.11	0.39	0.85	0.0001*
	Post	48.00	63.00	53.57	4.67						
sn-Ls	Pre	10.00	15.00	12.25	1.81	2.38	1.01	0.28	1.78	2.99	0.0001*
	Post	11.60	17.70	14.63	2.25						
Pg-Li	Pre	14.10	25.00	20.67	3.80	4.27	2.15	0.60	2.97	5.57	0.0001*
	Post	21.70	27.60	24.93	2.11						

*Significant difference as P<0.05

Transverse measurements

Table 3 represents the pre and post transverse measurements. The difference between pre- and post treatment measurements and comparison between them was performed by using Paired t test which revealed that:

There was a significant change in all measurements with P value < 0.05.

Table (3): Minimum, maximum, mean, and standard deviation of pre and post transverse linear measurements and comparison between them using Paired t test:

Linear Measurements (Transverse)		Minimum	Maximum	Mean	Standard Deviation	Paired Differences					P value
						Mean	Standard Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
									Lower	Upper	
Al[Rt] - Al[Lt])	Pre	32.30	38.40	34.45	2.12	0.88	0.40	0.11	0.64	1.12	0.0001*
	Post	33.00	38.70	35.33	2.08						
ULP[Rt] - ULP[Lt]	Pre	8.50	14.80	11.18	2.50	0.32	0.50	0.14	0.01	0.62	0.04*
	Post	9.10	14.50	11.50	2.05						
Ch[Rt]-Ch[Lt]	Pre	40.00	50.30	44.08	3.40	0.89	0.24	0.07	0.75	1.04	0.0001*
	Post	41.00	51.00	44.98	3.40						
ck [RT] to ck [LT]	Pre	80.50	90.00	86.57	3.66	4.30	1.74	0.48	3.25	5.35	0.0001*
	Post	85.80	95.40	90.87	3.20						

*Significant difference as P<0.05.

Angular measurements

Table 4 represents the pre and post angular measurements. The difference between pre- and post treatment measurements and comparison between them was performed by using Paired t test which revealed that:

There was a significant change in all measurements with P value < 0.05

Table (4): Minimum, maximum, mean, and standard deviation of pre and post angular measurements and comparison between them using Paired t test:

Angular measurements		Minimum	Maximum	Mean	Standard Deviation	Paired Differences					P value
						Mean	Standard Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
									Lower	Upper	
Sl-n-Sn	Pre	3.90	12.20	8.77	2.95	-0.72	0.26	0.07	-0.88	-0.56	0.0001*
	Post	3.00	12.00	8.05	2.96						
Sn-ls-li-pg	Pre	128.00	158.30	147.30	10.11	-3.35	1.50	0.42	-4.26	-2.44	0.0001*
	Post	124.70	156.30	143.95	10.74						
NLA	Pre	95.00	113.00	102.58	7.13	9.70	1.19	0.33	8.98	10.42	0.0001*
	Post	102.50	124.20	112.28	7.87						
n-prn-pg	Pre	123.00	135.00	128.38	4.61	-3.20	2.55	0.71	-4.74	-1.66	0.0001*
	Post	118.00	132.40	125.18	5.35						

*Significant difference as P<0.05.

Ratio:

Table 5 represents the pre and post ratio measurements. The difference between pre- and post treatment measurements and comparison between them was performed by using Paired t test which revealed that:

There was a significant change in all measurements with P value < 0.05

Table (5): Minimum, maximum, mean, and standard deviation of pre and post ratiomeasurements and comparison between them using Paired t test:

Ratio		Minimum	Maximum	Mean	Standard Deviation	Paired Differences					P value
						Mean	Standard Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
									Lower	Upper	
MH/MW	Pre	0.29	0.53	0.37	0.08	0.04	0.02	0.01	0.02	0.05	0.0001*
	Post	0.32	0.53	0.40	0.07						
UFH/LFH	Pre	0.98	1.32	1.09	0.11	-0.03	0.04	0.01	-0.06	-0.01	0.01*
	Post	0.97	1.29	1.06	0.11						

*Significant difference as P<0.05.

Discussion

Antero-posterior measurements

After taking pre-treatment and post-treatment measures for the thirteen patients in our study, we found that:

Middle facial depth (sn-tm) : there was a significant decrease after retraction and closure of extraction space and this leads to enhancement of the facial profile. These findings were in accordance with **Baik HS (2007)** [17]. Who showed a decrease of about 5 mm which occurs due to retraction of the upper lip. This leads to an obtuse naso-labial angle which allows for profile enhancement. While **Drobocky and Smith (1989)** [1].Stated that extraction affect facial profile to an extent that leads to a dish in face.

The upper lip to Eline, **lower lip to Eline, sulcus superior to Eline, and sulcus inferior to Eline :** all showed a significant decrease between before and after treatment and this was due to retraction of lips that follow the retraction of teeth and this was in accordance to results found by **Scott R et al(2006)**[18].But in contrast to results found by **Finnöy et al (1987)** [19]., **Drobocky and Smith (1989)** [1]., **Bravo LA (1994)** [7]. This could be due to the fact that their studies were performed by extraction of both upper and lower premolars while in our study only upper premolars were extracted.

Vertical measurements

Lower facial height there was a slight increase in lower facial soft tissue height due to the increase occurred in lower lip length these results was in accordance to results shown by **Baik SH (2007)** [17].

An increase occurred in both **Upper lip length** and **lower lip length** after treatment showing a strong correlation with maxillary incisor anteroposterior retraction. There was a significant increase in sn-Ls by 2.38 ± 1.01, while in Pg-Li there was a significant increase by 4.27 ± 2.1, and this was due to the relief of protrusion stress on lips after retraction. Similar results were shown by **Solem RC (2013)** [20]. While **Kusnoto J (2001)** [5]. Stated that the increase in both upper and lower lip lengths may be related to the attachment of the lip to the nose.

Transverse measurements

There was a mild difference between pre and post treatment measurements in transverse dimensions. The changes occurred due to retraction mainly affects the antero-posterior dimension but transverse one was less affected in accordance to **Baik SH (2007)** [17].

The mouth width and upper vermilion area appeared to be stable after the extraction treatment. The significant decrease in the philtrum width may be related to the changes in Chpr and Chpl in the horizontal dimension like findings conducted by **LinhuiShen et al (2020)** [21].

But the cheek width had a significant increase ranging from 4.30 ± 1.74 mm as it was affected by the strain from protruded teeth before retraction, like the results shown by **Baik SH (2007) [**17].

Angular measurements

Three-dimensional facial analysis is no longer un-familiar to orthodontists, and an orthodontic diagnosis should not only be based on absolute values, such as linear distances, but should also consider relative values, such as angles and proportions. With this in mind, the 3D facial model can be a template for 3D analysis with individual size calibration.

Maxillary prominence (sl-n-sn) there was a small amount of decrease occurred after treatment as both sl and sn subjected to the same changes after retraction, and similar results were shown by **Allgayer S (2011)** [22].

Labial convexity (sn-ls)-(li-pg):

There was a significant decrease by -3.35 ± 1.5 degree from pre to post measurements as retraction of both upper and lower teeth help in enhancing the angle of labial convexity. This was in accordance with results found by **Bravo LA (1993)** [23].

Nasolabial angle (sn tangent to nose and snls):

There was a significant increase by 9.7 ± 1.19 and became more obtuse enhancing the facial profile, which is similar to the results found by **Bravo LA (1993)[23].** And **Kusnoto J(2001)**[4].

Facial convexity including the nose (n-prn-pg):

Decreased by about by -3.2 ± 2.55 degrees following the decrease occurred in antero-posterior dimensions after teeth retraction. This had proven that there was a strong correlation between the nose and retraction of anterior segment and it was similar to the results shown by **Allgayer S (2011)** [22]

Ratios

Mouth height (chpm-Li) /mouth width (chR-chL) showed a statically significant increase by 0.04± 0.02, while Upper face height (n-sn)/ lower face height (sn-pog) showed a statically significant decrease by -0.03 ± 0.04.

But these results are not clinically significant .This goes with **Ricketts (1957)** [24]. Who stated that the proportion of the total anterior face height to the inter-zygomatic point distance was considered to be standard.

Similarly, **Baik et al (2007)** [25]. Found same results. He stated that these ratios were mainly based on vertical and transverse dimensions which showed slight changes after retraction.

CONCLUSIONS

1. The overall results showed that planmeca promax proface reproducing the texture and color of soft tissue, reconstructing 3D images immediately on related software and any point to point measurements could be easily obtained .

2. The upper and lower lips retracted by a noticeable amount that leads to an increase in their lengths.

3. Also a noticeable changes occurred to the profile of the patients.

RECOMMENDATIONS

1. Further studies using higher resolution 3D laser-scanned images are needed to assess more facial details, as our laser scanner is subject to image stretching and distortion in some facial areas.
2. Further studies to correlate the amount of skeletal changes that occur after extraction with soft tissue changes.
3. Further studies using different extraction patterns.

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