Research Article

Prospective Comparison of Facial Soft Tissue Changes Using 2D Photographs and 3D Scanning After En Masse Dentoalveolar Maxillary Distalization Using Tads

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ABSTRACT

Introduction: This prospective clinical study was undertaken to analyse the three-dimensional facial soft tissue changes after en-masse maxillary distalization using 3D structured light-based scanner and facial photographs and to compare the two diagnostic aids.

Materials and Method: 12 Indian adult patients of 17- 23 years of age with unilateral or bilateral class II molar relationship and those indicated for en-masse distalization. A pre-operative and post-operative extra oral 3D scan and 2D photographs were obtained for each subject. A prospective comparative evaluation of 10 lateral and 20 frontal soft tissue parameters was done.

Result: When pre to post comparison was made in different study parameters using paired t test, none of the study parameter showed significant difference.

Conclusion: The laser facial scanning can be considered as a useful and reliable tool to analyze the circumoral region for orthodontic and orthognathic surgical diagnosis and treatment planning. The difference in facial soft tissue changes evaluated using 3D scans and 2D photographs was also not statistically significant.

KEYWORDS: Facial Soft tissue changes, en-masse distalization, 3D structured light based scanner, 3D Vs 2D, Photographs.

INTRODUCTION

Achievement of harmonious soft tissue profile is one of the important treatment objectives. Class II division 1 malocclusion is one of most common malocclusions seen in day-to-day practice[1]. The majority of the patients with class II division 1 malocclusions have the presence of underlying skeletal discrepancy between maxilla and mandible.[1] They are characterized by proclined upper incisors, protrusive upper lip leading to a convex profile.[1]

The treatment of skeletal class II division 1 depends upon the age of the patient, growth potential, severity of malocclusion, and compliance of patient.[1] The common treatment alternatives for adult skeletal class II patients are camouflage treatment and surgical correction.[2] In camouflage treatment, the premolars are extracted to resolve crowding, retract the incisors, and provide Class I canine relationship. Another way of camouflage treatment is molar distalization. There have been many methods to distalize molars with intraoral or extraoral appliances, such as using a pendulum appliance, distal jet, or headgear.[3,4]

Many a times the soft tissue profile of the patient does not dictates an extraction treatment. In such non extraction cases sagittal movement of the entire dentition with the help of mini-screws minimizes the side effects with no special compliance required.[5,6,7]

Mini-screws offer various advantages and can accomplish molar distalization, posterior distalization and en-masse maxillary distalization with minimal side effects.[8] Distalization of the whole dental arch using mini-screws was recently published and showed good treatment results.[5,6,7] Special considerations and monitoring during en-masse distalization include three dimensional control of the second molar, monitoring of occlusal canting due to intrusive force vector, arch form for expansion and the anterior torque.[8] Recently, three-dimensional(3D) imaging techniques have been developed to evaluate facial soft tissue more accurately.[9] Acquisition methods of 3D imaging can be divided into cone beam computed tomography and non-contact optical scanning methods, such as laser-based scanners or structured light–based scanners.[10]

The structured light-based scanner used in this study was a USB powered portable hand-held scanner compatible with Windows® 8 and 10. It uses a short-range scanning technology from Intel® with a full HD colour camera. The aim of this study is to have prospective comparison of facial soft tissue changes using 2D photographs and 3D scanning after en-masse dentoalveolar maxillary distalization using TADs.

MATERIAL AND METHODS

A. 3D structured light scanner "Sense" (figure 1)
B. Software for scan evaluation: MeshLab 2020
C. Digital single lens reflex camera: DSLR (Nokia D300 with lens 18-55 mm) (figure 2)
D. Software for photographic evaluation: Corel DRAW 2020

Sample size estimation: The sample size estimation was done by using GPower software (version 3.0). The power of the study was taken to be 80% and Confidence Interval (C.I.) of 95% ($p<0.05$). The sample size was estimated to be a minimum of 8 as assessed from a similar study.

Sample distribution: 25 bimaxillary protrusion orthodontic patients within the age group of 18 to 23 years indicated for fixed orthodontic treatment with all four first premolar extraction.

INCLUSION CRITERIA

1. Class II molar relationship, unilateral or bilateral.
2. Patients indicated for en-masse dentoalveolar maxillary distalization.
3. Patients in the age group 17- 23 years.

EXCLUSION CRITERIA

1. Patients requiring any surgical correction or having mutilated occlusion.
2. Patients who have previously undergone orthodontic treatment.
3. Patients with any congenital deformity.
4. Patients who do not give consent to be part of the study.

Preoperative 3D scan*, using hand held 3D structured light scanner "Sense" of individual subjects was taken. After completion of en-masse distalization using IZC implants a post distalization scan of facial soft tissues was recorded.

The patient was instructed to relax the lips and set the head in a natural position, while the scan was taken. Scanning was done from ear to ear frontally and vertically from hairline to the most prominent soft tissue point on the chin i.e., pogonion. The scanner was moved 1800 around the patient's face to record the landmarks.

A facial model was obtained directly by scanning the faces using "sense" 3D scanner shown in figure 1 using the software MeshLab for calibrations.

To evaluate facial soft tissue changes after en-masse distalization easily identifiable, reliable reference points were chosen for the comparative measurements and are listed in the below mentioned Table 1 and 2.

Preoperative 2D photographs (frontal and lateral) of individual subjects were taken using Digital single lens reflex camera (Nikon D300 with lens 18-55 mm, figure 2) at a standard distance of 1.5 mm. The 2D photographs were taken in normal rest position, in normal daylight conditions.

The photographs were standardized by using a tripod set up and a chair placed at 1.5 meters distance from camera lens which was marked using a green tape. The focal length was set to 70 mm to standardize the magnification also.

Magnification error was further removed by measuring the inter-pupillary distance of the patient and calibrating it in the software Tracker™ using a calibrating Stick. Every reading was recorded three times by three different operators and the average reading was recorded in the proforma of the patient for the purpose of the study. Other parameters were then measured to scale in accordance to this reference measurement.

The facial measurements were done on 2D photographs using Coral 2020 software both pre and post measurements as shown in figure 3,4. The facial dimensions were recorded to the nearest millimetres (mm) from the 2D facial images. The software automatically calculated all the measurements identified on each landmark record, which were then transferred to Microsoft excel.

The measurements were repeated on 3D scan using MeshLab 2020 figure 5,6, both pre and post facial were recorded. The subjects also had to clear their head and neck region from any interfering jewellery, clothing elements or glasses as these factors can trigger artifacts by intensely reflecting the light during data recording. Patients were informed about the study and their consent for participation was taken. Clearance from the concerned ethical committee was obtained before proceeding with the study.

Figure 1 : 3D Scanner "Sense

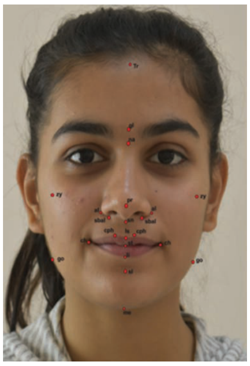
Figure 2 : DSLR NOKIA D300

Anthropometric landmarks used in the study[11] TABLE 1

Landmarks	Region	Definition
tr-trichion	Cranial	Midpoint of the hairline
g-glabella	Cranial	The most prominent point in the median sagital plane between the supraorbital ridges
n-nasion	Face	The midpoint of the nasofrontal suture
mf-maxillofrontale	Nose	The anterior lacrimal crest of the maxilla at the frontomaxillary suture
pr-pronasale	Nose	The most protruded point of the nasal tip
al-alare	Nose	The most lateral point on the nasal ala
sbal-subalare	Nose	The point on the lower margin of the base of the nasal ala where the ala disappears into the upper lip skin
sn-subnasale	Face	The junction between the lower border of the nasal septum, the partition that divides the nostrils, and the cutaneous portion of the upper lip in the midline
cph-crista philter	Orolabial	The point on the crest of the philtrum, the vertical groove in the median portion of the upper lip, just above the vermilion border
ls-labialesuperius	Orolabial	The midpoint of the vermilion border of the upper lip
ch-cheilion	Orolabial	The outer corner of the mouth where the outer edges of the upper and lower vermilions meet
sto-stomion	Face	The midpoint of the labial fissure when the lips are closed naturally
li-labialeinferius	Orolabial	The midpoint of the vermilion border of the lower lip
sl-sublabiale	Face	The midpoint of the labiomental sulcus
Me-menton	Face	The lowest point in the midline on the lower border of the chin
zy-zygion	Face	The most lateral point on the zygomatic arch
go-gonion	Face	The most lateral point at the angle of the mandible
ft-frontotemporale	Cranial	The most medial point on the temporal crest of the frontal bone
fz-frontozygomaticus	Cranial	The most lateral point on the frontozygomatic suture

Standard anthropometric measurements[11] TABLE 2

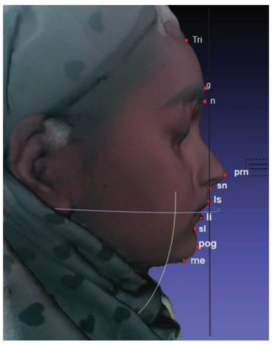
Region	Measurement name	Plane	Landmarks
Facial	Chin height	Vertical line	sublabiale-gnathion
	Lower face height	Vertical line	subnasale-gnathion
Oral-labial	Philtrum width	Horizontal line	crista philtre-crista philtre
	Philtrum length	Vertical line	subnasale-labialesuperius
	Upper lip length	Vertical line	Subnasalestomion
	Lower lip length	Vertical line	stomion-sublabiale
	Cutaneous lower lip height	Vertical line	labiale inferius-sublabiale
	Lower vermilion height	Vertical line	labialeinferius-stomion
	TVLA	Horizontal line	True vertical to A point
	TVLB	Horizontal line	True vertical to B point
	TVLLS	Horizontal line	TVL to labiale superius
	TVLLI	Horizontal line	TVL to labiale inferius
	SLINEU	Horizontal line	S line to upper lip
	SLINEL	Horizontal line	S line to lower lip
	ELUL	Horizontal line	E line to upper lip
	ELLL	Horizontal line	E line to lower lip
	NLA	Angular	Naso-labial angle
	TVLPOG	Horizontal line	True vertical line to pogonion



Facial landmarks in frontal view (Figure 3) in 2D photographs
(tr-trichion, g-glabella, n-nasion, mf-maxillofrontale, prpronasale, al-alare, sbal-subalare, sn-subnasale, cph-crista philter, ls-labialesuperius, ch-cheilion, sto-stomion, lilabialeinferius, sl-sublabiale, Me-menton, zy-zygion, gogonion, ft-frontotemporale, fz-frontozygomaticus)

Facial landmarks in lateral view (Figure 4) in 2D photographs
(G-glabella, N- nasion, Mn- mid nasal, Prn- pronasal, Cm, Sn-subnasal, Ls-labial superior, Li-labial inferior, SL- sub labal, Pg-pogonion, Me- menton, C-cervical, Trg- tragus, Ort point- junction of true vertical and true horizontal.)

Facial landmarks in frontal view (Figure 5) in 3D scan
(tr-trichion, g-glabella, n-nasion, mf-maxillofrontale, prpronasale, al-alare, sbal-subalare, sn-subnasale, cph-crista philter, ls-labialesuperius, ch-cheilion, sto-stomion, lilabialeinferius, sl-sublabiale, Me-menton, zy-zygion, gogonion, ft-frontotemporale, fz-frontozygomaticus)



Facial landmarks in lateral view (Figure 6) in 3D scan
(G-glabella, N- nasion, Mn- mid nasal, Prn- pronasal, Cm, Sn-subnasal, Ls-labial superior, Li-labial inferior, SL- sub labal, Pg-pogonion, Me- menton, C- cervical, Trg- tragus, Ort point- junction of true vertical and true horizontal.)

QUANTITATIVE ASSESSMENT OF FACIAL MORPHOLOGY

A total of 20 facial landmarks - were identified twice on each of the 2D and 3D images. To place the landmarks on the 2D images, Coral 2020 was used. Meshlab was used for landmark identification on the 3D images.

Following landmarks were used for frontal/ lateral analysis. (Figure 3,4,5,6)

RESULTS

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 21.0, IBM Inc. Descriptive data was reported for each variable. Descriptive statistics such as mean and standard deviation for continuous variables was calculated. Shapiro Wilk test was used to check the normality of the data. As the data was found to be normally distributed bivariate analyses was performed using Independent t test and paired t test. Level of statistical significance will be set at p-value less than 0.05.

Measurements of difference in soft tissue changes in 2D photography and 3D scanning TABLE 3

Parameter		N	Mean	Std. Deviation	Std. Error Mean	P value
chin	Photographic change	12	-.2283	.43902	.12674	.124
	Scanned change	12	.0883	.10794	.03116	
LFH	Photographic change	12	-.1033	.26979	.07788	.620
	Scanned change	12	-.1733	.40012	.11551	
PHILW	Photographic change	12	-.0317	.29606	.08547	.304
	Scanned change	12	.1317	.44869	.12953	
PHILL	Photographic change	12	-.5017	.52503	.15156	.151
	Scanned change	12	0.30	0.70	0.20	
ULL	Photographic change	12	.3575	.36632	.12951	.277
	Scanned change	12	.0983	.57848	.16699	
LLL	Photographic change	12	-.1667	.42498	.12268	.577
	Scanned change	12	-.0750	.36649	.10580	
CLLH	Photographic change	12	.1317	.47560	.13729	.396
	Scanned change	12	.2683	.26937	.07776	
LVH	Photographic change	12	-.1200	.38134	.11008	.030
	Scanned change	12	.1517	.14173	.04091	
TVLA	Photographic change	12	.83	.24618	.07107	1.000
	Scanned change	12	0.247	.24618	.07107	
TVLB	Photographic change	12	-.0333	.68135	.19669	.671
	Scanned change	12	.0833	.64784	.18702	
TVLLS	Photographic change	12	.9617	.53191	.15355	1.000
	Scanned change	12	.9617	.53191	.15355	
TVLLI	Photographic change	12	.6767	.33800	.09757	1.000
	Scanned change	12	.6767	.33800	.09757	
SLINEU	Photographic change	12	1.0833	.70173	.20257	1.000
	Scanned change	12	1.0833	.70173	.20257	

Parameter		N	Mean	Std. Deviation	Std. Error Mean	P value
SLINEL	Photographic change	12	1.2500	.78335	.22613	.803
	Scanned change	12	1.1667	.83485	.24100	
ELUL	Photographic change	12	.5667	.34466	.09949	.344
	Scanned change	12	.7000	.33029	.09535	
ELLL	Photographic change	12	.7500	.39886	.11514	1.000
	Scanned change	12	.7500	.39886	.11514	
NLA	Photographic change	12	1.02	6.24657	1.80323	.181
	Scanned change	12	-.8400	8.39848	2.42443	
TVLPOG	Photographic change	12	-1.2667	3.62768	1.04722	1.000
	Scanned change	12	-1.2667	3.62768	1.04722	

When pre to post comparison was made in different study parameters using paired t test, none of the study parameter showed significant difference. When pre to post comparison was made in different study parameters using paired t test, none of the study parameter showed significant difference.

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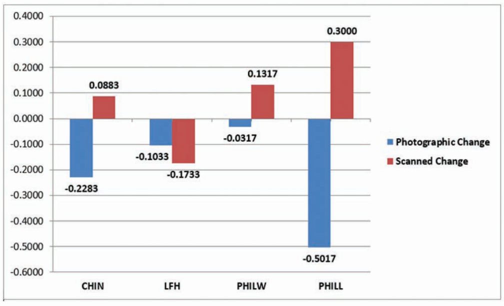
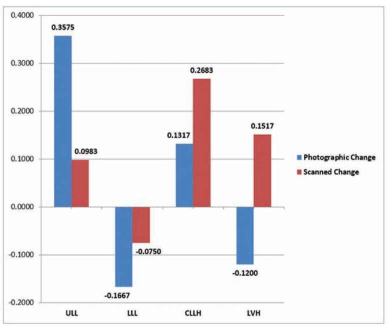
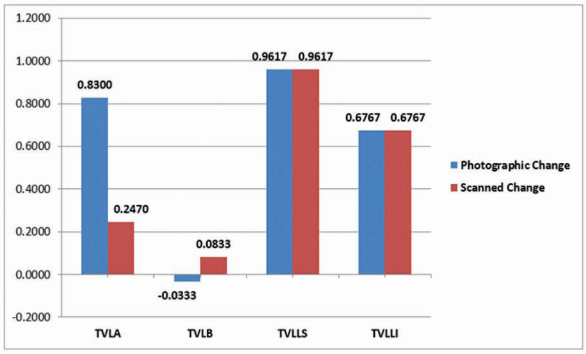
Pre and post treatment changes in soft tissue among two groups : chin length, lower anterior facial height, philtrum width and philtrum length. **Figure 7**



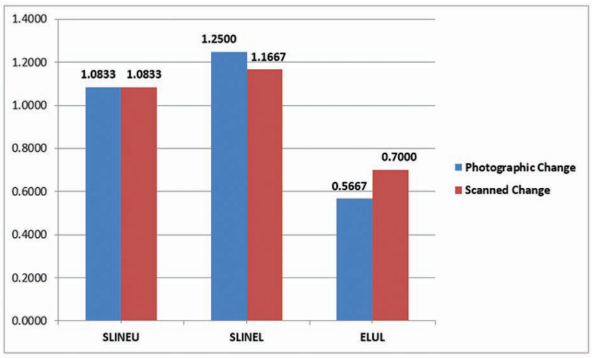
Pre and post treatment changes in soft tissue among two groups : Upper lip length, lower lip length, Cutaneous lower lip height and Lower vermilion height. **Figure 8**



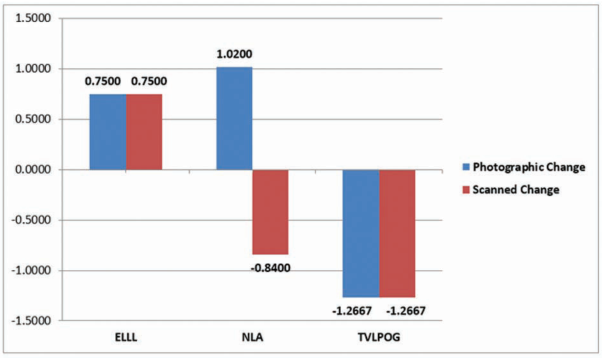
Pre and post treatment changes in soft tissue among two groups : True vertical to A point, True vertical to B point, TVL to labiale superius and TVL to labiale inferius. **Figure 9**



Pre and post treatment changes in soft tissue among two groups : S line to upper lip, S line to lower lip and E line to upper lip. **Figure 10**



Pre and post treatment changes in soft tissue among two groups : E line to lower lip, Naso labial angle and True vertical line to pogonion. **Figure 11**



There was no significant difference seen in lateral and frontal parameters when 3D scans were compared with 2D photographs using t test as p>0.05. When difference in mean change in different study parameters between photography and scanning group were analysed using independent t test, none of the parameter was found to be statistically significant as p>0.05.

DISCUSSION

Laser scanning is a non-invasive, non-ionizing imaging technique, which captures the facial soft-tissues in three dimensions. The purpose of this study was to evaluate the clinical applicability of currently available 3D facial scan by comparing 3D facial scans to 2D facial photographs. The study was done to mimic clinical orthodontic diagnostic analysis, where professionals rely on the clinical standard ratios and angles for their treatment planning. The use of facial frontal and lateral landmarks were selected according to article by Alimohamad Asghari.[12]

It is a common practice in orthodontic treatment planning to use 2-D photographs as a means of diagnostic aid, determining the start and end-points of orthodontic treatment. In the present scenario the clinical picture becomes important where TADS are being used, to be precise about diagnosis, treatment planning and treatment outcome. Enciso et al.[13] in 2004 stated that the 2D images in assessing facial morphology is subject to errors because the natural 3D facial anatomy will be translated in 2D.

In the present study Infrazygomatic crest mini-screws were used for en-masse distalization. It is an effective treatment tool to correct Class II malocclusions. Also, IZC mini-screws were used in accordance to the studies conducted by Lin14 and Lee S15 to ensure bicortical engagement and 10-12 Oz (284-340g) of distalizing force, the present study used 300g of force for distalization by class I elastics.

Fontana et al[16] in 2011 did lateral cephalometric study to observe soft tissue changes following molar distalisation with various distalisation appliances and found slight upper lip retrusion and lower lip protrusion which was clinically insignificant.

In the present study with respect to 2D and 3D linear and angular measurements there was no significant difference in the frontal and profile measurements after en-masse distalization. This is in accordance to a study conducted by Mitiksha et al[17] in 2019 quantifying the effects of cephalometric changes following en-masse maxillary arch distalization with TADs in Angle's Class II division 1 patients. Retraction of lips observed from pre to post Distalization was found to be statistically non-significant. It was concluded in the study that Distalization did not produce any soft tissue changes. Mostly dental changes were noted to convert a class II to class I dental relationship. Also, in the same study it was seen that TADs assisted en masse distalisation prevents round-tripping of the incisors and there is no force to move the anterior teeth forward as they do not retract the incisors by taxing the anchorage as seen in conventional distalisation appliances which lead to protrusion of the lips.

In the present study statistically non signification retraction is seen with respect to upper lip and lower lip. This may be due to the fact that molar distalization seen was not enough to bring about significant incisor retraction. The posterior teeth were distalized sufficiently to resolve crowding and there was no change in the orthognathic profile after distal movement of the anterior teeth. Also in the present study retraction of incisors due to en masse distalization was not significant enough to bring about changes in facial profile measurements like TVL-pt A, TVL-Pog, TVL-Ls, TVL-Li, nasolabial angle and TVL-pt B .

Changes in the positions of incisors have a direct impact on the supporting soft tissues. However, a difference in soft tissue thickness and lip tension produces a complex variation in profile as demonstrated by hard tissue changes. The amount of change in lip positions after the retraction of anterior teeth may differ among different ethnicities, gender and types of malocclusions.

The interradicular space between molars may limit the amount of en-masse retraction. Recent computed tomography imaging studies showed that the average amount of mesiodistal bone between the first molar and second premolar is 3.3 mm.[18,19.] To gain additional space for distal movement, the IZC TADs were used and angulated at 30-40° superiorly to the perpendicular of a plane tangent to the buccal cortical bone. Paik et al.[20] reported that about 3 mm of upper-first-molar distalization can be expected. Bechtold et al.[21] reported that interradicular mini-screws for the correction of a full cusp Class II relationship will inevitably need to be removed and reinserted during treatment[21,22] which could be cumbersome for both the operator and patient. Hence, this technique could well be indicated for the correction of end-to-end Class II, rather than full cusp Class II. It has been shown that the damage to the root surface by the titanium mini-screw during tooth movement is reversible[23].

In the present study the nasolabial angle increased but not significantly (P = 0.736). In this study, the position of the upper lip was found to be more retracted, but this difference was not significant (P =0.769). Longitudinal studies by Bishara[24] also concluded similar results. This is in concurrence to Ahmed M. Shoaib[25] and Jae Hyun Park[26] study to evaluate skeletal, dentoalveolar, and soft tissue changes at 3 years post treatment in patients with Class II Division 1 malocclusion distalized with modified C-palatal plates (MCPPs).

The present study did not show any significant difference in facial soft tissue changes measured using 2D photographs and 3D scans after en masse maxillary distalization using TADs. This is in contrary to Van Vlijmen et al27who reported a statistically significant difference between the 2D and 3D measurements. Although, these methods serve as veritable tools in the study of facial morphology for varying purposes, they cannot be used interchangeably, more especially in clinical evaluation of facial form diagnosis. The fact that there is a statistically significant difference between two-dimensional and three-dimensional images, the 2D facial models can still be used especially when assessing or evaluation of facial dimensions with less significant differences.

CONCLUSIONS

Based on the findings of the present study, the following conclusions can be made:

- There were no statistically significant facial soft tissue changes after en masse dentoalveolar maxillary distalization as measured through 2D photographs.
- There were no statistically significant facial soft tissue changes after en masse dentoalveolar maxillary distalization as measured with the help structured 3D light scanner.
- The difference in facial soft tissue changes evaluated using 3D scans and 2D photographs was also not statistically significant.
- Nevertheless, the laser facial scanning can be considered as a useful and reliable tool to analyze the circumoral region for orthodontic and orthognathic surgical diagnosis and treatment planning. In order to take full clinical advantage of this new technology, 3D facial scanning could be combined with CBCT to measure the changes in facial soft-tissues.

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