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The validity of using profile predictions for class III patients planned for bimaxillary orthognathic surgery

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ABSTRACT

This study assessed whether pre-operative class III patients could recreate their facial difference based on a profile photograph. Twenty class III pre-surgery bimaxillary orthognathic patients used CASSOS (SoftEnable Technology Ltd.) to manipulate a distorted soft tissue image of them until they felt it resembled their current soft tissue profile. Patients were able to move their upper lip and lower chin backward and forwards, as well as the lower chin up and down. Differences in the mean absolute distance between the patient-perceived position of the upper lip (Labrale superious) and chin (Pogonion) and the actual position of their upper lip and chin were measured on two occasions. Intra-patient reproducibility was found to be excellent (ICC 0.93 to 0.98). All differences were statistically significantly greater than 3mm, and would be clinically significant. Patients were better at re-creating their AP chin position rather than their AP upper lip and vertical chin positions. Approximately half of patients undergoing surgical correction of their class III skeletal pattern were unable to correctly identify their pre-surgical facial profile. Given the lack of awareness of their profile, this questions the validity of using profile planning for informed consent.

Keywords: self-perception; facial profile; photocephalometeric planning; prediction planning; 3D planning

INTRODUCTION

Facial attractiveness has many well-reported social advantages.[1] Attractive individuals are known to have several positive personality traits.[2,3] The importance of facial appearance in this ever-increasing world of social media is arguably more important than ever, especially among the younger age group.[4] There has been a paralleled increase in the number of cosmetic procedures undertaken by individuals. For instance, there has been a 60% increase in Botox injections from 2012 to 2019 with over 2.3 million injections performed in 2019.[5]

Individuals with a facial difference will often require orthognathic surgery to address their functional and aesthetic concerns. Part of the treatment planning process involves predicting the soft tissue outcomes following surgery. Sharing this with the patient is essential for gaining informed consent but also for increasing their understanding and acceptance of the recommended treatment.[6] Patients are more likely to be satisfied when they are involved in the decision-making process.[7,8] At present several methods to predict the outcome of surgery are available. These include model surgery[9], two-dimensional (2D) photocephalometric planning[10,11] and three-dimensional (3D) planning.[12,13] Two-dimensional cephalometeric planning is a well-established method of predicting soft tissue outcome following surgery. However, in the United Kingdom, not all NHS hospital Orthodontic / Maxillofacial Departments have access or routinely use 2D photocephalometeric planning software. Anecdotally, in the Departments that do, some maxillofacial surgeons are anxious showing any soft tissue profile predictions to the patients. They feel that the predictions may increase patient expectations, and lead to a dissatisfied outcome. The premise for this assumption must be that patients know what they look like in profile prior to and after surgery. Given that, as individuals, we frequently see frontal or portrait views of ourselves i.e. with selfies and traditional camera views, and more often mirror views of ourselves, is this a valid assumption?

Therefore the aim of this study was to assess whether pre-operative class III patients can recreate the severity of their facial difference based on a profile photograph. The null hypothesis was that the mean absolute difference in the patient-perceived position of the upper lip (Labrale superious, Ls) and chin (Pogonion, Pog) and the actual position of their upper lip and chin was not statistically significantly ($p<0.05$) greater than the 3.0mm clinical threshold.[14]

METHOD AND MATERIALS

This prospective study included 13 males and 7 females (mean age 22.0 years ± 6.0 months) who attended the joint orthognathic clinic, between July 2018 and November 2019 and were planned for bimaxillary surgery to correct their class III skeletal pattern (mean Wits -9.7 ± 3.2mm). Patients were non-syndromic and had no significant facial asymmetries.

MATERIALS AND METHODS

Computer-Assisted Simulation System for Orthognathic Surgery (CASSOS) (SoftEnable Technology Ltd., Hong Kong) software installed on a Dell Latitude 3340 Intel Core i3 13.3' screen Laptop was used to produce a morphable profile image.

For each patient a digital lateral cephalograms was taken in a standardised manner with Frankfort Plane parallel to the floor, lips in repose, and teeth in intercuspal position (ICP). The radiographs were uploaded into CASSOS and seventy-one pre-determined hard and soft tissue landmarks were identified generating a ‘tracing’. The visual information below Subnasale backwards, on the lateral cephalogram, was redacted, leaving on the soft tissue profile. A ‘matched image’ was generated by superimposing the redacted lateral cephalogram and the right profile photograph, Figure 1.

For each patient the starting point of each soft tissue profile outline was altered by advancing the chin anteriorly horizontally (x-axis) and vertically / inferiorly (y-axis) by 10mm and the maxillary horizontality posteriorly by 10mm. The first image the patients saw of themselves was the altered image.

Patients were shown a demonstration of the process using a mock profile. They were asked to manipulate their profile outline visible on screen, using the arrow keys, until they felt it resembled their current soft tissue profile, Figure 2. The soft tissue profile was saved (T_1) and following a 15-minute break each patient was asked to repeat the procedure and the second profile saved (T_2).

Finally each patient was asked to anonymously answer the following questions (1). Would you find it more helpful to see a 3D image of your face or a 2D profile image during the surgical planning stage? (2). Do you think the extra radiation exposure during the 3D scan (CBCT) would be “worth it” if it allowed you to see yourself in 3D before surgery?

Bland Altman plot was produced to show the bias and levels of agreement (LoA) between the mean differences in actual upper lip and chin position and patient- perceived position in the anterior-posterior (AP) direction and vertical directions. A negative value indicated the patient perceived landmark was more posterior or more superior in the x and y direction respectively, than the actual soft tissue landmark.

STATISTICAL ANALYSIS

Differences in Labrale superious (Ls) and Pogonion (Pog), in the x and y directions, between the actual patient profile and their perceived profile were extracted relative to Nasion (0, 0). The data was found to be normally distributed based on the Anderson-Darling test. The intraclass correlation coefficient (ICC) was used to determine intra-patient reproducibility. To prevent averaging of positive and negative values, as the signs refer to the direction, absolute mean values were used. A one-sample *t*-test was used to determine whether the mean absolute differences in the actual and perceived lip and chin position, in both the AP direction and vertical directions were significantly different to 3.0mm ($p<0.05$).

RESULTS

Sample size calculation

Following a sample size calculation (Minitab 19, State College, PA) 20 participants were necessary to determine whether the mean absolute difference in actual and perceived lip and chin position, were greater than 3.0 mm[14] , based on a significance level of 0.05, power of 80%, and standard deviation (SD) of 4.5mm.

Intra-patient reproducibility

The intra-patient reproducibility was found to be excellent (ICC score range 0.93 to 0.98). The mean absolute differences in AP upper lip and AP and vertical chin position between the T_1 and T_2 were 1.8 ± 2.1mm, 2.2 ± 2.2mm and 1.8 ± 1.4mm respectively.

Upper lip position relative to Nasion

The mean absolute difference in the actual and perceived lip was not statistically significantly different to 3.0mm (p=0.860), Table 1. There was a bias towards under advancing the upper lip and producing a more retrusive upper lip, accompanied with a large variation in response, Figure 3.

Chin position relative to Nasion

The mean absolute difference in the AP actual and perceived chin position was not statistically significantly different to 3.0mm (p=0.811). The Bland-Altman plot shows the bias towards producing a more protrusive chin position, Figure 4. For the vertical direction the mean absolute difference was statistically significantly greater than 3.0mm (p=0.017). The Bland-Altman plot shows the bias towards placing Pogonion more inferiorly, Figure 5. The wide limit of agreement from 12.8mm to -3.5mm suggests the large variation in perceived vertical chin position, Table 1.

Inter lip-chin relationship

The horizontal and vertical distances of the upper lip (Ls) to the chin point (Pog) were used to measure the relative position of the chin to the upper lip. Both the mean absolute differences between the actual and perceived Ls-Pog horizontal distance were statistically significantly greater than 3.0mm.

Responses of patients to 3D planning

Four out of the twenty patients reported they were concerned with the additional radiation exposure of a CBCT scan needed to produce a 3D prediction and would not find a 3D predication of any additional value.

DISCUSSION

This novel study determined whether patients with a class III facial disharmony were able to recreate their pre-surgical soft tissue facial profile. For two-dimensional photocephalometric prediction planning to be a valid form of media for patient communication, managing expectations and informed consent, the assumption must be that patients have a perception of their pre-surgical soft tissue facial profile, before presenting them with the profile prediction. Some surgeons are uncomfortable showing patients' their predictions, as they feel it may lead to unrealistic patient expectations. This creates a dilemma, the patient is undergoing an elective procedure to address their facial difference, but the surgeons are unwilling to show them the outcome. This could be seen as a paternalistic approach to treatment where the patient has no option but assume the surgeon "knows best". From a legal perspective this approach is no longer acceptable and is by no means informed consent.[15]

The results of the present study showed that out of the 20 class III patients, 9 patients correctly identified the AP position of their upper lip and 11 patients their AP chin position to within the 3mm clinical threshold.[14] Of these, only 5 patients correctly identify both their AP upper lip and chin positions. Based on the mean differences, there was a tendency for patients to under advance their upper lip i.e. positioning it more retrusive than it was in reality (-2.3 ±

3.0mm) and position their chin in approximately the correct AP position (0.8 ± 3.7mm). Twelve patients correctly identified their anterior-posterior upper lip / chin relationship. In the vertical direction, only 6 patients were able to position their chin correctly to within the 3mm clinical threshold. There was tendency for patients to position their chin more inferiorly than in reality. For this cohort of patients the mean absolute difference between the actual and perceived lip and chin positions for all measurements were 3mm or greater. One possible explanation for better AP chin point position may be that the chin is well defined and is an isolated feature, whist the perception of upper lip position may be influenced by the surrounding soft tissue i.e. nasal tip position, columella inclination or malar projection. There may be several reasons why patients produce a soft tissue profile that exaggerates their AP class III skeletal pattern and increased vertical dimension. It could be that patients do not know what they look like in profile, or patients have a distorted view of themselves, or patients are trying to guide the surgical plan. Reassuring the patients their identified images would not be used in the surgical decision-making process would have hopefully negated the effect of the later.

Previous studies have used silhouettes to assess facial attractiveness.[16-18] The present study used the patient's actual soft tissue profile, which could be "morphed", in real-time, in CASSOS. This allowed the individual to move their soft tissue and produce a smooth photorealistic image of their profile. Using conventional photo-editing software would have produced an image, that would have had gaps, and steps that could distract from the final image, similar to the 1:1 profile predications.[9] Previous studies have reported that only 42% of lay people were able to choose the correct silhouette, which best represented their facial profile.[17,18] This means over 50% of lay people are unable to recognise themselves in profile.

The authors acknowledge that the direction and amount the pre-surgical image was manipulated may affect the patient's ability to accurately recreate the various soft tissue positions. A future study could involve manipulating the pre-surgical images to both extremes, making a class III patient look class II versus an exaggerated class III and investigating the effects of orthodontic decompensation. This was beyond the scope of this study, but would be interesting.

As individuals, we rarely see ourselves in profile and are accustomed to viewing our faces from the frontal view, as a reflected frontal view in the mirror. de Runz et al (2016) reported a significant preference for mirror-reversed photographs over standard photographs among female patients who are undergoing facial aesthetic surgery.[19] This could also be of significance in orthognathic patients who were seeking correction of a mandibular asymmetry. We acknowledge that there may be a difference in facial perception between males and females and possibly between racial groups but was beyond the scope of this study, but does warrant further investigation.

If around half of class III patients do not know what they look like in profile, then the use of soft tissue profile predictions as a visualisation tool becomes questionable. The information provided by the computerised predication may not be in a format that the patients can not relate too and therefore may not be the ideal media for them to make an informed decision. The profile predictions maybe of some limited benefit in explaining the “general surgical plan” to the patient, but their use as an absolute indicator of outcome is probably of little benefit.

Even though three-dimensional orthognathic planning is routinely available in many centres outside of the UK, many NHS orthognathic teams do not have access to this method of planning, either due to cost, lack of specialised equipment or lack of expertise. In addition to this, there are concerns regarding the additional radiation exposure during the CBCT scan and the perceived advantages of using 3D orthognathic planning techniques. The majority of the patients in this study were millennials and were accustomed to viewing three-dimensional (3D) media in the form of video games and movies. It was therefore not surprising that 16 out of the 20 patients would have found it more helpful to see a 3D image of themselves following 3D surgical planning. Given the 3D nature of the face, it is not surprising that patients want to see themselves in 3D. This would be of greater significance in patients with a mandibular asymmetry. Whether the patients could correctly identify the severity of their class III skeletal pattern and whether they prefer the mirror-reversed view remains unknown and requires further work.

CONCLUSIONS

This study has shown approximately half of patients planned for surgical correction of their class III skeletal pattern could not correctly identify their pre-surgical facial profile. Patients were better at determining their anterior-posterior chin position than their upper lip position. The use of two-dimensional photocephalometric planning, as a tool for informed consent, may therefore be questionable, given that patients may not know what they look like prior to surgery, let alone after surgery. Generating a 3D facial soft tissue prediction maybe more useful as a patient information tool, but this requires further investigation.

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CONFLICT OF INTEREST

None

ETHICS STATEMENT/CONFIRMATION OF PATIENT PERMISSION

Ethical approval was been granted by the Health Research Authority ([redacted]). Consent for publication of images has been given.

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CAPTIONS FOR ILLUSTRATIONS

Figure 1 Matched lateral cephalogram with lower half redacted (white box) and soft tissue profile (red line) with right profile photograph superimposed.

Figure 2 Simulation of profile based on patient-perceived appearance of a non-class III individual used in demonstration.

Figure 3 Bland and Altman plots for patient-perceived and actual anterior- posterior upper lip (Ls) position.

Figure 4 Bland and Altman plots for patient-perceived and actual anterior- posterior chin (Pog) position.

Figure 5 Bland and Altman plots for patient-perceived and actual vertical chin (Pog) position.

TABLE LEGEND

Table 1 Descriptive statistics for the mean and absolute mean differences between Labrale superious (Ls) and Pogonion (Pog), in the anterior-posterior (AP) and vertical (Vert) directions, between the actual patient profile and perceived profiles.

TABLE 1

	Actual position		Patient-perceived position		(Patient-perceived position) – (Actual position)								p-value
	Mean (mm)	SD (mm)	Mean (mm)	SD (mm)	Mean difference (mm)	SD (mm)	95% CI for the differences (mm)		Absolute Mean difference (mm)	SD (mm)	95% CI for the differences (mm)		
							Lower limit	Upper limit			Lower limit	Upper limit	
Ls (AP)	13.4	3.2	11.1	4.0	-2.3	3.0	-3.7	-0.9	3.1	2.2	2.1	4.1	0.860
Pog (AP)	13.1	5.6	13.9	6.0	0.8	3.7	-0.9	2.5	3.1	2.0	2.2	4.0	0.811
Pog (Vert)	102.4	8.5	107.0	9.5	4.7	4.2	2.7	6.6	5.1	3.6	3.4	6.8	0.017*
Ls – Pog (AP)	0.3	4.4	-2.7	5.4	3.1	3.9	-0.1	6.3	3.2	2.5	2.1	4.4	0.749
Ls – Pog (Vert)	-39.4	4.5	-43.8	6.3	4.4	3.9	0.9	7.9	4.4	3.9	0.9	7.9	0.015*

*Following a one sample *t*-test with a hypothesised mean of 3.0mm ($p<0.05$)

Figure 1

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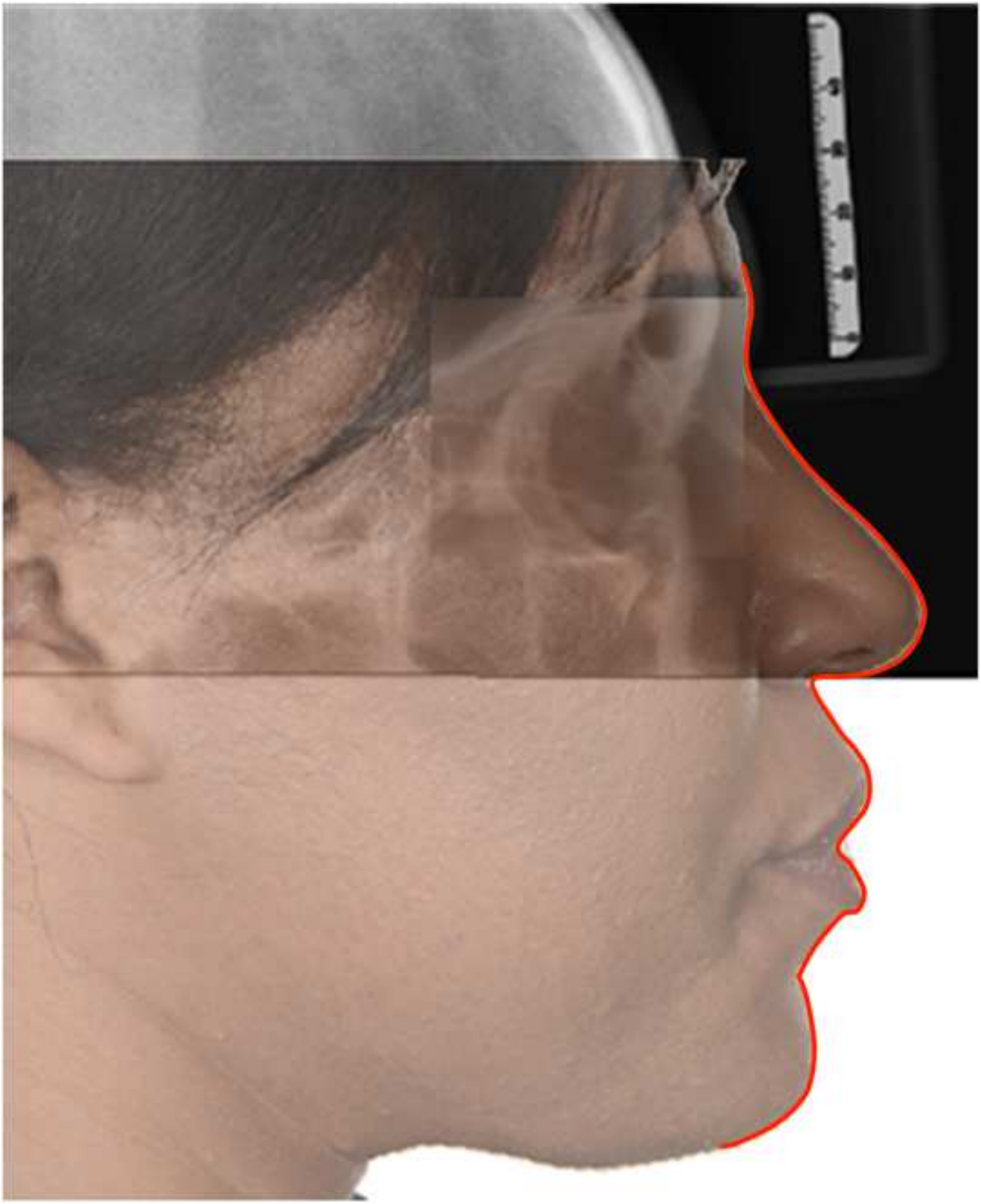

Figure 2

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Figure 3

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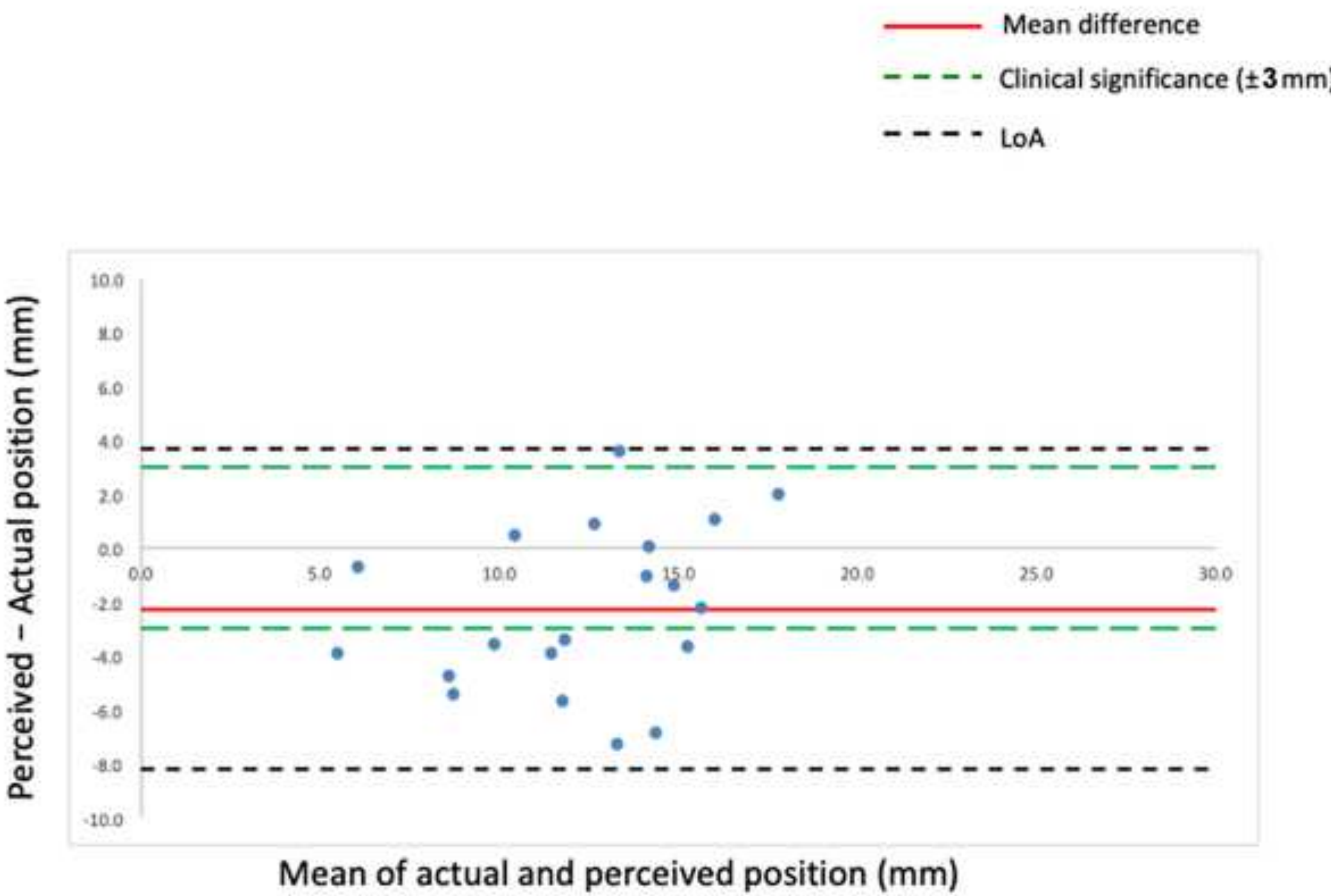

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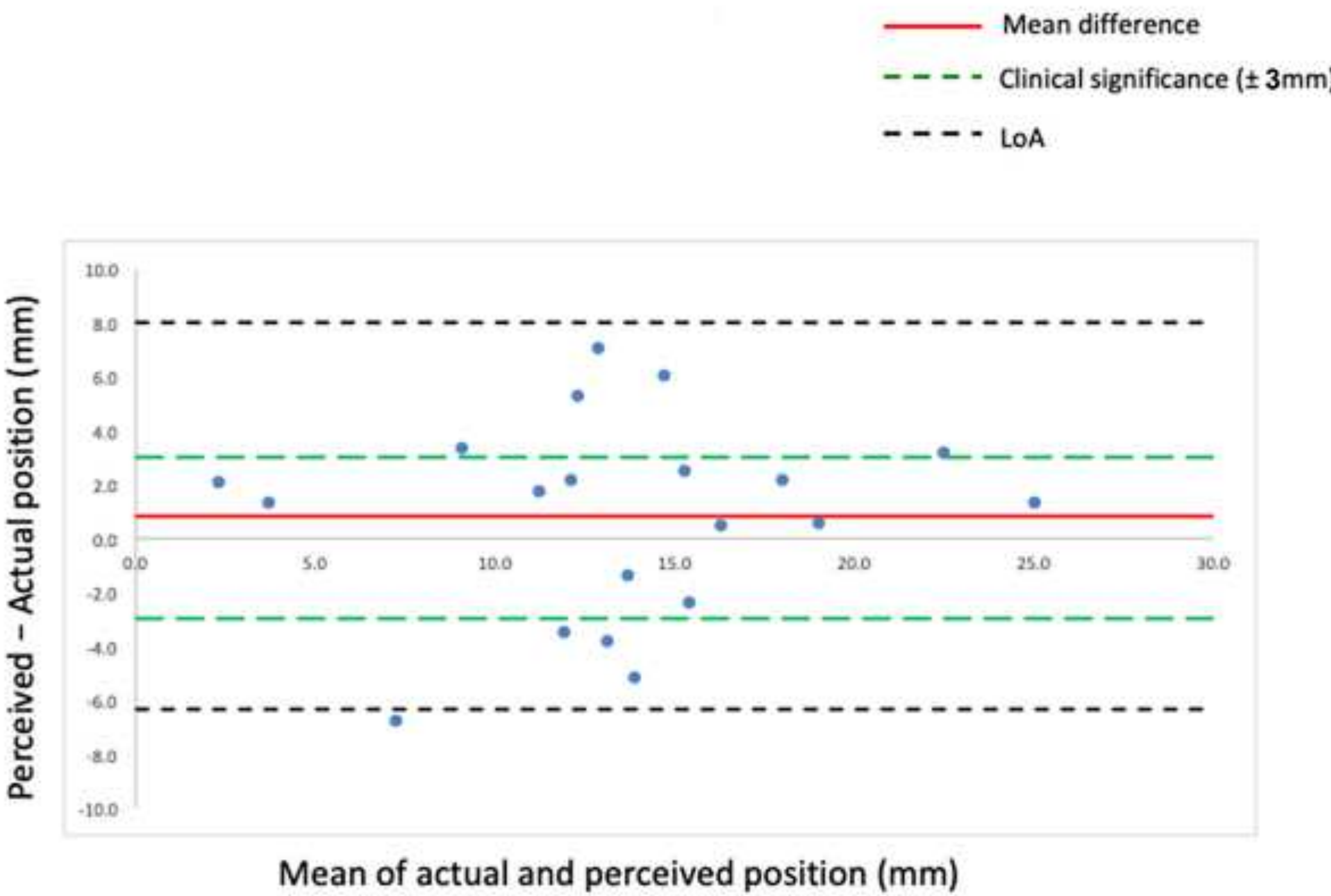

Figure 5

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