Orthognathic patient perception of 3D facial soft tissue prediction planning.

Abstract

The primary aim of this study was to explore patients' perceptions regarding the impact of 3D prediction planning of facial soft tissue changes following orthognathic surgery.

The study was carried out on patients who were shown a photorealistic 3D soft tissue prediction planning before undergoing orthognathic surgery to demonstrate the expected facial changes. Distraction osteogenesis and cleft deformities were excluded from the study before consenting to surgery. Following surgery, they were then asked to complete a standard questionnaire to explore their perception regarding the impact, accuracy, and value of 3D prediction planning.

Results; Thirty patients were included in this study, the majority of participants perceived 3D PP to be beneficial in reducing their presurgical anxiety, increasing their motivation to undergo surgery, improving the accuracy of their surgical expectation, and enhancing doctor-patient communication. Most of the patients perceived the surgical soft tissue changes to be better than the prediction. Positive significant correlations were detected between the satisfaction with the delivered service and the facility of seeing 3D PP (r_S =0.4; p=0.034). Similarly, the 3D PP improved patients' confidence in the surgical decision (r_S=0.4; p=0.031), as well as augmenting their motivation to undergo surgery (r_S =0.5; p=0.010).

In conclusion, 3D PP was found to be effective in improving the quality of orthognathic surgical care.

Keywords:

Orthognathic; 3D prediction; soft tissue; planning

Introduction

Orthognathic surgery produces irreversible changes in facial appearance and can have a significant impact on quality of life. Despite the recent advances in the three-dimensional “3D” facial imaging and digital orthognathic planning, there is a lack of knowledge regarding patients’ perception of the impact of prediction planning (PP) of the expected postoperative changes. The number of patients having a malocclusion severe enough to warrant treatment by a combined orthodontic and surgical approach in the UK in 2001 was predicted to be approximately 250,000 patients (Templeton *et al.,* 2006), and this number is gradually increasing (Moles and Cunningham, 2009). Contemporary care models require a partnership between the patient and the multidisciplinary team, with the patient actively involved in their treatment planning (Vervier and Ziefle, 2016; Bergkulla *et al.,* 2017). Involving patients in the decision making process reduces their dissatisfaction, the expression of which can range from complaints to lawsuits (Krause *et al.* 2001).

Orthognathic surgery has a profound physical and psychological impact and might dictate whether a patient feels immediate satisfaction or regret (Carvalho *et al.,* 2013). Patient’s understanding of the expected surgical changes is crucial to provide assurance and enhance postoperative satisfaction. With the increase in patients’ demands, the role of prediction planning has become even more important (Bengtsson *et al.* 2018). Accurate prediction planning is also imperative for achieving excellent facial aesthetic results (Mundluru *et al.,* 2017) and the patient’s perspective does not

always relate to the objectively measured 'success' of the treatment outcome (Khattak *et al.,* 2012). Patients with clear improvements in facial appearance expressed dissatisfaction, despite the absence of surgical complications. Thus, understanding patients' expectations is key to improving satisfaction (Posnick and Wallace 2008).

Studies have already reported on the accuracy of three-dimensional prediction planning (3D PP) of soft tissue changes following orthognathic surgery (Mundluru *et al.,* 2017). Nevertheless, there is still some debate regarding the importance of showing the patients the 3D PP of facial changes as part of their preparation for orthognathic surgery . It is perceived by some that 3D PP may raise unrealistic expectations of the surgical changes, which may lead to patient dissatisfaction and possible litigation. However, these concerns are not based on clear evidence, and little is known about the patients' perspective on the value of 3D PP of soft tissue facial changes following orthognathic surgery. This knowledge gap inspired our team to undertake this study. Therefore, the aim of this study was to explore patients' perceptions regarding the impact of 3D PP of the expected photorealistic facial soft tissue changes before undergoing orthognathic surgery. Postoperatively, they were asked to answer the question as to whether this facility is useful part of the orthognathic treatment pathway.

Material and Methods

This was a retrospective single cohort study, using a self-administered questionnaire. Approval to conduct this study was given by the local management committee, (GGCNHS/20/03/20)

The study was carried out on a group of orthognathic patients who received clinical care under the same multidisciplinary team comprising a surgeon, orthodontist,

clinical psychologist, and maxillofacial technologist. The patients were shown the 3D PP of the expected soft tissue, skeletal and dental changes in response to surgery. Patients having distraction osteogenesis, secondary corrective procedures and cleft deformities were excluded from the study.

Each patient was invited to view the 3D PP on the screen of a standard personal computer. The duration of the session was approximately 10–15 minutes, and the following protocol was followed with each patient:

a. The presurgical jawbones and dental occlusion were displayed to demonstrate where the osteotomy cuts would be performed using a validated Maxilim orthognathic software package (Shafi *et al.,* 2013).
b. The 3D photorealistic soft tissue was applied to highlight the areas of deficiency which will be addressed by surgery
c. The surgical movements of the osteotomy segments were displayed with an explanation of the magnitude and direction of each one
d. The 3D PP of the soft tissue changes following surgery was displayed from various directions highlighting the expected improvements.
e. The preoperative images and the 3D PP were displayed side by side to allow the patient to visualize the expected changes (Figure 1).
f. Each patient was given the opportunity to use the software to rotate and view the 3D PP. This usually took approximately 5 minutes for the patients to fully understand and appreciate the expected changes (Figure 2)
g. Additional procedures including genioplasty and zygomatic augmentation where indicated, were demonstrated part of the decision-making process. The pros and cons of the procedures were discussed until a mutual decision was reached.

h. Patients were given a printout of the latest publication related to the accuracy of 3D PP of soft tissue changes following various orthognathic surgical procedures. All patients were warned that the accuracy of the prediction was limited to 85%, based on published data (Shafi, *et al,.* 2013, Mundluru *et al,.* 2017).

The planning session for all patients was conducted on a one-to-one basis, in a pre-determined sequence, by the surgeon.

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Following this session, patients were invited to sign their surgical consent form.

Following surgery, patients were asked to complete a customised questionnaire (Appendix 1) to evaluate the impact of 3D PP. We assessed the validity of the questionnaire; Eleven questions were valid (score >0.3) (Appendix 2). The validity was less in one question related to the patients' confidence to have a simultaneous genioplasty, which is understandable as this procedure with only offered to a limited number of cases. To assess the reliability of the questionnaire Cronbach's alpha test of internal consistency was used. A score of 0.818 proved excellent reliability.

The questionnaire consisted of three major sections. The first was standard demographic data. The second section measured presurgical anxiety, motivation, surgical expectation, communication, accuracy of the prediction, and overall satisfaction with treatment experience. In this section, the patients expressed their level of agreement or disagreement using five-point Likert scales for each question, which ranged equally from strongly disagree, disagree, neither agree nor disagree, agree or strongly agree. In the last section, the participants were invited to comment on how our 3D PP service could be improved.

Patient responses of 1 and 2 on the Likert scale were categorised as disagreement toward the statement, whereas responses of 4 and 5 were categorised as agreement toward the statement. A response of 3 was categorised as neutral.

Statistical analysis

Shapiro Wilk's normality test was applied, and Mann-Whitney test was used to evaluate the association between two ordinal variables. Kruskal-Wallis test explored the association among several variables. Differences were deemed significant if $p < 0.05$ and highly significant if $p < 0.001$. Spearman's correlation (r_s) was applied to quantify the strength of the relationship between the level of patient satisfaction with 3D PP and the measured variables. A value of r_s = 0-0.3 was considered weak positive linear relationship; 0.4-0.6 indicated a moderate positive linear relationship; and 0.7-0.9 indicated a strong positive linear relationship (Dancey, et al., 2014).

Results

A total of 30 patients (23 females and 7 males) participated in this study, table 1 shows the demographic details of with an age range of 17 to 62 years (table 1). Ten patients underwent Le Fort I osteotomy with genioplasty, 10 underwent bilateral sagittal split osteotomy and the remaining 10 underwent bimaxillary osteotomy. The Shapiro-Wilk normality test confirmed that the data were not normally distributed.

Mann-Whitney U test revealed no statistically significant difference ($p<0.05$) in the satisfaction level with 3D PP between males and females (p=0.413) or between high school and university graduates (p=0.787). A Kruskal-Wallis test showed no statistically significant difference in the satisfaction level with 3D PP between the age subgroups, (teenager, adolescent, adult or elderly) (p=0.401), or the motivation

subgroups (internal, external or both) (p=0.171). Thus, our results suggest that demographic factors did not influence the level of satisfaction with 3D PP.

Table 2 shows that most of the patients' scores were in the 3 to 5 range for all questions. This was reassuring, but the limited spread of data reduced the strength of the correlations among the assessed variables.

Figure 3 shows the overall impact of 3D PP on the tested variables. In the presurgical anxiety domain, most of the patients (83.3%) reported a positive impact of 3D PP, and the majority (93.3%) confirmed that they considered the viewing of their 3D PP to be beneficial before undergoing orthognathic surgery.

In the motivation domain, 86.7% of the patients confirmed that 3D PP reassured them of their decision to proceed with surgery, and it enhanced motivation to undergo surgery in 73.3% of patients.

In the surgical expectation domain**,** 96.7% of patients indicated that the ability to manipulate their 3D PP image on the screen and view it from all angles, gave them a better understanding of the desired outcome of their planned surgical procedure, and for 80% of patients, it helped them to have a realistic expectation of their planned surgical changes.

In the doctor-patient communication domain, 80% of patients reported that 3D PP encouraged them to participate in the discussion about their surgery, and 56.7% of the patients found that it proved useful in helping them decide on the need for an adjunctive genioplasty. For 83.3% of the patients, 3D PP allowed them to take part in the decision-making process and augmented their confidence towards the surgeon and the team providing their treatment. The final decision regarding the surgery was taken jointly by both the surgeon and the patient. Based on the 3D PP none of the

patients refused to be operated upon, three cases reversed their decision regarding an adjunctive genioplasty.

Sixty percent of the patients reported that their final surgical result was better than the prediction, and the remainder indicated that their results were similar to the prediction. The majority of the patients (93.3%) were satisfied with their 3D PP experience and felt that it should be an essential part of the orthognathic treatment pathway.

Table3 shows the mean scores recorded by the patients of each of the 12 variables assessed in the study. The highest mean score was related to the impact of 3D PP in reducing anxiety and improving the overall satisfaction with the provided surgical procedure.

The four most essential aspects of 3D PP that patients found helpful to see were bone, chin, teeth, and nose. Most respondents (n=19) felt that a few weeks before surgery would be the ideal time to be shown their 3D PP, while almost 50% of them indicated that 3D PP should be shown at an earlier diagnostic stage to help them decide whether to proceed with surgery.

Positive significant correlations were detected between the satisfaction with the delivered service and the facility of seeing 3D PP (r_S =0.4; p=0.034). Similarly, the 3D PP improved patients' confidence in the surgical decision (r_S=0.4; p=0.031), as well as augmenting their motivation to undergo surgery (r_S =0.5; p=0.010).

Discussion

indicated that Illustrative videos have been shown to improv patients' education and reduced their anxiety substantially in preparation for surgery (Rossi et al., 2004). The

3D photorealistic images provide a life-like reflection of facial morphology (Naudi *et al.,* 2013). In our study, 83% of patients agreed that 3D PP reduced their presurgical anxiety or stress, and 93% indicated that they would prefer to see 3D PP if they were given the choice. The 3D nature of the prediction proved helpful, one of the patients commented "*It really helped me know what I was going to look like near enough after surgery because beforehand it was making me really stressed out not knowing how I would look".* Therefore, showing the photorealistic 3D PP to the orthognathic patient prior to surgery is beneficial in reducing presurgical anxiety.

Ryan et al., (2012) found that patient expectation was one of the determinants of satisfaction with treatment. The results of our study showed that 96.7% of patients believed that being able to visualise the 3D morphology of the face enabled them to have a better understanding of their planned surgical changes. This agrees with Wu and Chiang (2013), who found that 3D animation was useful in reducing cognitive loading and enhancing the effectiveness of learning. Additionally, 3D PP provided a medium that facilitated patient interaction with the surgeon and enabled them to receive an answer to each of their queries and concerns. Patients felt that they took part in the decision-making process when they were given an opportunity to manipulate the image of their face on the computer screen. This finding is congruent with Evans and Gibbons (2007), who found that multi-media learning facilitated knowledge transfer and enhanced understanding. It also aligns with the explanation that the ability to manipulate the image improves patient knowledge from an educational perspective (Pulijala *et al.,* 2016).

Maal et al., 2008 reported that the fusion of the 3D stereophotogrammetry of the face and the CBCT image of the skull, provided an accurate, photorealistic model of the patient's face. They believed that the accuracy and photorealistic model are

beneficial for diagnosis, presurgical planning, and communication with patients). Our study confirms that 3D PP was useful for visualising the jawbones, the dentition, and the overlying soft tissues of the face which helped the patient-surgeon communication.

Our results showed that 80% of the patients believed that they were more confident regarding their decision to proceed with surgery after seeing 3D PP, and 83.3% agreed that their confidence in the surgeon increased, which is likely to improve patients' satisfaction. Patients commented specifically on the 3D of the shown image, *"Fully understanding from all angles and directions how I would potentially look after surgery as I had no idea".* Patients also highlighted that 3D PP helped them during the recovery period, "*Better idea of what changes would look like and what to expect after surgery. If recovery had looked drastically different, would have known what to watch out for".* Positive interaction between the patients and surgeon has been shown to improve satisfaction with received treatment (Dimovska *et al.* 2016, Xia *et al.* 2000).

Patients who are provided with accurate information tend to be more satisfied with their treatment (Cunningham et al., 1996). Our findings indicate that in the eyes of the patients, the surgical results were better than the 3D PP, which is reassuring and acts as a safeguard to avoid unrealistic expectations from the patients' side, which may be a concern for some surgeons. It has to be emphasised that the study did not assess the accuracy of the 3D soft tissue prediction, since this has been considered in our previous publications, (Al Mukhtar et al.,2016, Mundluru et al., 2017, and Al Mukhtar et al.,2018) and other studies (Bengtsson et al., 2018, Ferraz et al., 2021, Karanxha et al., 2021)

The developed questionnaire in this study was based on the Post-Surgical Patient Satisfaction Questionnaire(PSPSQ) by (Ostler, Kiyak, 1991), We also

incorporated a Patient Recorded Experience Measure (PREM) developed by the clinical psychologist in the multidisciplinary team. Despite the proved validity we appreciate the limited interindividual reliability testing

The reason for conducting this study on postoperative patients was to allow the impact of 3D PP on the overall satisfaction with orthognathic surgery to be assessed, as well as evaluate the patients' perception regarding the accuracy of the prediction planning of the soft tissue changes.

The design of the study did not allow a comparison with patients who did not experience 3D PP or may have been shown other methods of surgical planning. However, the aim of this study was focused on assessing the impact of 3D PP as part of our routine orthognathic practice, and its effect on the patients' confidence as well as their stress and anxiety. The limitations of 2D prediction planning are well documented especially in relation to asymmetric cases, Contemporary 3D prediction planning have gone some way to overcome these deficiencies. The authors accept that other multidisciplinary teams may consider alternative methods of prediction planning to augment patients' confidence and alleviate their apprehension. A comparative study with these methods would be interesting but beyond the scope of this study.

We recommend future studies to investigate the impact of other modalities of prediction planning or other methods of communication on patient confidence and satisfaction with orthognathic treatment. Multicentre studies would augment the sample size and include patients of various ethnic and social background.

The modest sample size in this study reflects the nature of this investigation which was exclusively focused on a group of patients following a standard protocol of orthognathic treatment delivered by one multidisciplinary team. The strength of our conclusions should therefore be taken in this context.

Conclusions

The 3D PP had a significant positive impact on the patients' experience of their orthognathic treatment journey. It reduced the presurgical anxiety, increased their motivation and confidence to undergo surgery, as well as improving the surgeon-patient communication. The 3D PP was realistic and did not overestimate the expected changes. We believe that 3D PP should be shown, whenever possible, in the management of dentofacial deformities and orthognathic surgical planning.

Declarations of interest

None

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Legends of the figures

Figure 1. The preoperative images and the 3D PP were displayed side by side to allow the patient to visualize the expected changes 3D prediction planning from various angles. The

worm-eyes of the face “A” and of the prediction planning “B”. Medio-lateral views of the face “C” and of the prediction planning “D”.

Figure 2. A patient in the study using the software to rotate and view the 3D PP,

Figure 3. The Likert scale of the impact of 3D prediction planning on anxiety, motivation, surgical expectation, patient-doctor interaction, accuracy and satisfaction

Table 1. Demographic Feature of included subjects	
Variable	Value
Age (yr)	
Mean	29.5 years
Median	29 years
Range	17 years – 62 years
Gender (%)	
Male	n=7; 23.3%
Female	n=23; 76.7%
Level of education (%)	
Secondary School	n=5; 16.7%
College, University of Higher Degree	n=25; 83.3%
Motivation for surgery (%)	
Internal	n=26; 86.7%
External	n=0; 0%
Both	n=4; 13.3%
Reasons for considering surgery(%)	
Aesthetic	n=24; 80%
Functional/ Physical	n= 29; 96.7%
Non-functional/ Psychosocial	n=25; 83.3%

Table 2. Tabulation of the Likert Score (1-5) for each of the 12 survey questions.

Score	Anxiety		Motivation & Confidence		Surgical expectation		Communication				Accuracy of the prediction	Satisfaction
	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q3	Q4	Q1	Q1
1	0	0	0	1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	1	0	0	1	0	0	0
3	5	2	4	7	1	5	6	13	4	5	12	2
4	17	7	14	12	12	18	11	7	18	10	3	7
5	8	21	12	10	17	6	13	10	7	15	15	21

Table 3. Patients' mean scores of the 12 measured variables

	Anxiety		Motivation		Surgical Expectation		Doctor-Patient Communication			
	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q3	Q4
Mean	4.10	4.63	4.27	4.00	4.53	3.97	4.23	3.90	4.03	4.33
Standard deviation	0.66	0.61	0.69	0.95	0.57	0.72	0.77	0.88	0.72	0.76

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