
**“EVALUATION OF THE ACCURACY OF DOLPHIN
IMAGING SOFTWARE IN PREDICTING SOFT
TISSUE CHANGES POST FIXED FUNCTIONAL
THERAPY – A RETROSPECTIVE OBSERVATIONAL
STUDY”**

By
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IN
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(BRANCH – V)**


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2022 – 2025

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ABSTRACT

Introduction: Improvement in facial esthetics is the most common motivation for seeking orthodontic treatment. To visually simulate and predict the orthodontic treatment outcomes, computerized profile and photograph prediction systems, such as Dolphin Imaging® can simulate the whole process of treatment by vivid, simple, and self-evident animations. The accuracy of computer-aided VTO prediction in soft tissue changes after orthodontic treatment using Dolphin Imaging software is still under debate.

Aim: To evaluate the accuracy of Dolphin VTO prediction in soft tissue changes after fixed functional therapy by comparing the changes between predicted and actual values of the soft tissue parameters.

Materials and methods: A total of 48 participants were included in the study based on the inclusion and exclusion criteria. The landmarks and parameters of the Holdaway soft tissue analysis were used for the cephalometric analysis. The cephalometric tracings of the actual treatment result and the Dolphin predicted treatment outcome were superimposed to calculate the prediction errors. Data collected was then statistically analysed for significance.

Results: Comparison between predicted and actual values of the soft tissue parameters post fixed functional therapy amongst the study participants was performed using Independent samples t-test. This comparison showed statistically significant differences (p value <0.05) for all parameters; except Convexity (A-Npo) (mm), Lower Lip to H-Line (mm), S.T. Angle (FH-NPg')(°) , Subnasale to H-Line (mm) and H- Angle (p value >0.05).

Conclusion: Despite the presence of statistically significant differences between the simulated and actual positions of specific landmarks, the majority of these differences were of insufficient magnitude to attain clinical significance. Hence, the Dolphin Imaging software could be considered as an alternative tool to predict soft tissue changes in orthodontic treatment with clinically acceptable accuracy.

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INTRODUCTION

Facial esthetics plays a momentous role in the psychological and social development of growing individuals¹. The perception of one's own facial appearance can influence self-esteem, social interactions, and overall quality of life.

Poor facial esthetics, such as malocclusions or asymmetries, may lead to lower self-confidence and social anxiety in children and adolescents who are highly influenced by societal beauty standards.

Fixed functional therapy is widely used in adolescent orthodontic treatment, particularly for correcting skeletal Class II malocclusions. This treatment modality enhances mandibular growth, improves occlusion, and optimizes facial esthetics, making it an effective option during the adolescent growth phase^{2,23}.

The ability to set goals beforehand and compare them with the outcomes at the conclusion of treatment makes a VTO prediction useful for the orthodontist's self-improvement. An objective view of the areas where the orthodontist's treatment could be refined is provided by identifying the differences between goals and results^{3,24,25}.

The Dolphin Imaging system is frequently utilized in creating visual treatment objectives (VTO), maintaining patient photos and videos, and carrying out cephalometric measurements and analysis. It can greatly enhance doctor-patient communication by simulating the entire course of treatment through realistic, user-friendly 3D animations^{4,25}. Nevertheless, it is still unclear how accurate computer-aided VTO forecasts are for soft tissue changes following fixed functional therapy employing Dolphin Imaging.

According to certain research, regions including the chin, submandibular region, and nasal tip may have a greater capacity for prediction^{5,18}. However, other research comparing software-generated predictions with real treatment outcomes has discovered clinically significant differences in every parameter. While its reliability for orthodontic therapy alone is still unclear, the majority of study on Dolphin VTO accuracy has been on orthognathic treatment, with or without orthodontic intervention^{6,7,19}.

Consequently, this study aims to offer more definitive information regarding the Dolphin predicted outcome of soft tissue alterations in patients undergoing fixed functional therapy.

AIMS AND OBJECTIVES

AIM:

To evaluate the accuracy of Dolphin VTO prediction in soft tissue changes after fixed functional therapy by comparing the changes between predicted and actual values of the soft tissue parameters.

OBJECTIVES:

- To assess the soft tissue changes post fixed functional therapy as predicted by dolphin imaging software
- To compare dolphin software predicted soft tissue changes to actual soft tissue changes post fixed functional therapy

HYPOTHESIS

NULL HYPOTHESIS:

There will not be a difference in the computerized soft tissue predicted values when compared to actual values of soft tissue changes after fixed functional therapy

ALTERNATIVE HYPOTHESIS:

There will be a difference in the computerized soft tissue predicted values when compared to actual values of soft tissue changes after fixed functional therapy.

REVIEW OF LITERATURE

1. Sanaz Soheilifar et al. (2022)

- This study focused on assessing the precision of Dolphin Imaging software in predicting soft tissue profiles in Class I patients undergoing fixed orthodontic treatment. Seventy individuals with borderline Class I malocclusion were split into two groups, one receiving extraction treatment and the other not.
- Following cephalometric evaluations, the software produced post-treatment visuals, which were superimposed over real clinical results. According to the study, the lips in the extraction group were more protruded than the software had expected.
- The only notable difference in the non-extraction group, on the other hand, was the lower lip's vertical posture, which looked worse in the simulation than it did in reality.

2. Maniyar N et al. (2024)

- The goal of this study was to evaluate Dolphin software's prediction accuracy in Class II Div. 1 malocclusion cases involving the extraction of all first premolars.
- The study used Dolphin version 11.95 to import the lateral-cephalograms of 30 young adults before and after treatment. Software-generated predictions were then compared to actual treatment outcomes by superimposing the tracings. Statistical comparisons were made using paired t-tests based on Holdaway's soft tissue analysis.

- The results highlighted measurable prediction errors between the expected and actual outcomes, underlining the software's varying degrees of accuracy.

3. Maryam Omidkhoda et al. (2022)

- This study evaluated how accurately Dolphin software could forecast soft tissue changes following orthognathic surgery.
- Involving 20 patients, pre and postsurgical cephalograms and facial photos were scanned and processed using Dolphin version 11.8. Cephalometric superimposition was performed to identify the extent of skeletal movement. The software then created simulated postoperative images based on these changes.
- The study concluded that Dolphin Imaging showed a reliable ability to predict both skeletal and profile alterations, particularly in upper lip region.

4. Arif AA et al. (2024)

- This study examined how well Dolphin software predicts changes in the soft tissue profile of the upper jaw in adult Class II Division 1 patients receiving extractions and those not receiving them.
- Of the 60 patients whose records were reviewed, 30 were in the extraction group and 30 were in the non-extraction group. Pre and post-treatment lateral cephalometric radiographs were traced using the software. The actual skeletal changes were input into the software's prediction module to simulate the anticipated soft tissue profile, which was then compared to the real post-treatment outcome.

- The findings revealed that the software's predictions were more accurate in non-extraction cases. In extraction cases, it tended to underestimate the retraction of the upper lip.

5. Tarek Elshebiny et al. (2019)

- Using Dolphin 3D software, this study evaluated the precision of three-dimensional soft tissue prediction in patients having orthognathic surgery.
- CBCT scans taken prior to surgery (T0) and six months post-surgery (T1) from 20 patients were imported into Dolphin 3D version 11.9. Virtual surgeries were conducted on the preoperative scans to replicate actual osteotomies, and predicted soft tissue images were generated. Differences between predicted and actual outcomes were measured through linear and angular assessments using surface mapping.
- It was concluded that while the software provided a general overview, its predictive accuracy was restricted in certain areas, especially around upper lip and nasal base.

6. Christel Buck Gossett et al. (2005)

- This research aimed to compare the predictive accuracy of computer-assisted surgical VTOs with conventional VTOs.
- Involving 31 patients, pre-surgical cephalometric tracings generated by Dolphin Imaging software were compared with actual post-surgical tracings. Sixteen different hard tissue landmarks were measured and statistically analyzed.
- The study found that the Dolphin VTO provided results comparable to traditional methods, making it a viable option for post-surgical cephalometric planning.

7. Tamar Kublashvili et al. (2004)

- The reliability of manual and automated soft tissue cephalometric measures was examined in this study.
- Using digitized conventional films and digital radiographs, the researchers evaluated eleven linear and four angular soft tissue measurements in two software systems—Dolphin 7.0 and Vistadent 8.0. The results from the software were compared with manual tracings using Holdaway’s and Steiner’s analyses.
- The study did not specify the exact sample size but used various subjects for reliability testing. It concluded that Dolphin software provided the most consistent results, closely matching manual tracings and demonstrating greater reliability.

8. Ahmad Akhondi MS et al. (2012)

- This comparative study evaluated soft tissue prediction accuracy between manual tracing and Dolphin Imaging software in patients undergoing orthognathic surgery.
- A total of 40 individuals (35 females and 5 males) were included. Each underwent evaluation using both manual and software-based tracing techniques. The accuracy and reliability of each method were statistically assessed using paired t-tests.
- The findings showed that the nasal tip had the highest prediction accuracy, whereas regions like the subnasale and upper lip (in vertical plane) and pogonion (in horizontal plane) exhibited less accurate predictions.

9. Guilherme Janson et al. (2012)

- This study compared soft tissue changes in Class II Division 1 malocclusion patients treated with either fixed functional appliances (non-extraction) or two maxillary premolar extractions. A total of 48 patients (96 lateral cephalograms) were analyzed.
- Both groups had similar treatment durations and initial overjet measurements. Statistical analysis using t-tests revealed no significant differences in soft tissue changes or post-treatment cephalometric outcomes between the two groups.
- Despite limitations in appliance and technique consistency, the findings suggest that both treatment approaches yield comparable soft tissue results in late pubertal patients.

10. Catia Quintao et al (2006)

- This study evaluated facial profile changes in Class II Division 1 patients treated with a twin block (TB) functional appliance. Thirty-eight patients (19 treated, 19 controls) with a mean age of around 9.5 years were assessed using lateral cephalograms over one year.
- After accounting for growth, the TB group showed significant facial profile improvements, including upper lip retraction and forward movement of the soft tissue pogonion aligning with underlying skeletal changes.
- No such improvements were observed in the control group, indicating the TB appliance enhances facial harmony in growing patients.

11. Ozge Celik Guler et al (2020)

- This study evaluated soft tissue changes in Class II Division 1 patients treated with three functional appliances—Twin-block (TB), Mono-block (MB), and Herbst (H)—using 3D imaging. Sixty patients were treated for approximately 9.5 months.
- All groups showed significant improvements in facial convexity angle, facial depth, and lower lip height. TB and MB groups also showed increases in upper/lower facial height and nasal width. Only the Herbst group showed a significant increase in lower facial width.
- Overall, all appliances contributed to favorable soft tissue and mandibular volumetric changes.

12. Burcin Akan et al (2020)

- This study assessed the effects of the Forsus appliance on facial soft tissues in Class II patients using cephalometric radiographs and 3D facial scans. Twenty patients were evaluated at three stages: before treatment (T0), after appliance removal (T1), and six months post-treatment (T2).
- Significant dentoalveolar changes were observed in measurements like overjet, overbite, and incisor positioning, with limited soft tissue changes. The study concluded that the Forsus appliance primarily produces dentoalveolar effects, and 3D facial scanning is a reliable tool comparable to traditional cephalometry.

13. Mary Varghese et al (2021)

- This prospective clinical study compared dentoskeletal changes in Class II patients (ages 14–16) treated with Forsus Fatigue Resistant

Device (FFRD) and Powerscope (PS). Twelve patients were divided into two equal groups.

- Both appliances showed significant maxillary restraint and vertical changes. Powerscope caused greater mandibular lengthening (4.06 mm vs. 3 mm) and lower incisor proclination (2.5 mm vs. 1.98 mm) than Forsus.
- Both devices effectively corrected Class II malocclusion, but Powerscope demonstrated slightly more favorable skeletal effects and incisor movement.

14. Kevin Nirayath et al (2023)

- This study evaluated the accuracy of Dolphin visual treatment objectives (VTO) in predicting treatment outcomes for Class II functional therapy. Pre- and post-treatment cephalograms and photographs were compared.
- The software accurately predicted most skeletal changes, except for lower anterior facial height. It was less accurate in predicting upper incisor proclination and some soft tissue parameters, such as the H angle and lower lip position.
- Overall, Dolphin VTO provided acceptable predictions for skeletal, dental, and soft tissue outcomes.

15. Shabbir Shah et al (2018)

- This study assessed the accuracy of positive clinical VTO in predicting post-treatment soft tissue profile changes in Class II Division 1 patients treated with a twin block appliance. Profile angles—nasofacial, nasomental, mentocervical, and nasolabial—were measured in 30 patients.

- Nasolabial (81.4%) and nasomental (68.1%) angles showed higher predictive success, while nasofacial and mentocervical angles had lower accuracy (~48%). Regression analysis confirmed significant predictive value for clinical VTO, especially for nasomental and mentocervical angles.
- The study concludes that while clinical VTO can guide profile improvement, orthodontists should be cautious in predicting treatment outcomes from growth modification.

16. Zhang et al (2018)

- This study evaluated the accuracy of Dolphin VTO in predicting soft tissue changes after orthodontic treatment in 34 young adults. Using Holdaway soft tissue analysis, predicted and actual treatment outcomes were compared.
- Significant differences were found, with lip region landmarks often overestimated horizontally and underestimated vertically, while chin region landmarks showed the opposite trend. The soft tissue A-point had the most accurate prediction, while chin region landmarks were least accurate.
- Overall, Dolphin VTO predictions were more accurate vertically than horizontally.

17. C.Topel Sievers et al (1999)

- This study assessed the accuracy of Ricketts' computer-assisted Visual Treatment Objective (VTO) over 2- and 5-year periods using lateral cephalograms of 180 patients.
- The VTO reliably predicted skeletal growth, including maxillary and mandibular positions, rotation, and craniofacial development.

However, it was less accurate in forecasting dental relationships, dentoskeletal relations, and soft tissue changes.

- Overall, the VTO provides a generally valid prognosis for skeletal growth but may not fully reflect treatment-influenced outcomes.

18. Carlos Flores-Mir et al (2006)

- This systematic review evaluated facial soft tissue changes after using fixed functional appliances in Class II Division 1 malocclusion cases. Five relevant clinical trials (four with Herbst, one with Jasper Jumper) were analyzed. Results showed statistically significant, but possibly clinically minor, soft tissue changes.
- Due to methodological flaws and limited evidence, conclusions should be interpreted cautiously. More robust, long-term, 3D-based randomized clinical trials are recommended for better insight.

19. Ersim Yildirim et al (2021)

- This retrospective study proposed a 3D evaluation method using CBCT to assess soft tissue effects of Twin Block (TB) therapy in Class II patients. Sixty pre- and posttreatment images were analyzed.
- Significant skeletal changes included decreased SNA and ANB, and increased SNB. Significant soft tissue improvements were observed in the lower lip, soft tissue pogonion, and gnathion, while upper lip and subnasale changes were not significant.
- The study concluded that 3D CBCT imaging effectively captures both skeletal and soft tissue improvements after TB therapy, particularly in the lower facial region.

20. Dima Almrayati et al (2024)

- This systematic review evaluated the effectiveness of functional orthodontic appliances (removable and fixed) on soft tissue changes in skeletal Class II adolescents. Eleven studies (3 RCTs and 8 CCTs) involving 689 patients were analyzed.
- Meta-analysis showed Twin Block treatment led to upper lip retraction and an increase in the nasolabial angle, while the lower lip position remained unchanged. Additional soft tissue angles like the mentolabial and Z-angle increased, and facial convexity decreased.
- 3D scans showed lower lip length and total face height increased, with no change in upper lip length or commissural width.

21. Gabbie Jasmine Kaur et al (2021)

- This study compared the skeletal, dentoalveolar, and soft tissue changes from Forsus Fatigue Resistant Device (FFRD) and PowerScope in Class II Division 1 malocclusion patients. Cephalometric records of 20 treated patients were analyzed.
- Both appliances effectively corrected Class II discrepancies. Skeletal changes were more prominent with Forsus, while dentoalveolar changes were greater with PowerScope. Both showed improvement in soft tissue profiles.
- The study concluded that both FFRD and PowerScope are effective treatment options, producing favorable changes across all three areas.

MATERIALS AND METHODS

STUDY DESIGN:

Retrospective Observational study

SOURCE OF DATA:

Pre and post- treatment lateral cephalograms of patients who have been treated with fixed functional therapy from the Department of Orthodontics and Dentofacial Orthopaedics in KLE V K Institute of Dental Sciences, Belagavi

SAMPLE SIZE ESTIMATION:

Formula

SD₁: Standard deviation in the 1st group

SD₂: Standard deviation in the 2nd group

$$n = ((Z_{(1 - \alpha/2)} + Z_{(1 - \beta)})^2 \times (SD_1^2 + SD_2^2)) / (\bar{x}_1 - \bar{x}_2)^2$$

where

$$SD_1 = 0.47$$

$$SD_2 = 0.39$$

$$\bar{x}_1 = 11.75$$

$$\bar{x}_2 = 12.00$$

$$\alpha = 0.05$$

$$1 - \beta = 0.80$$

Estimated sample size, $n = 47.1$

The sample size was estimated to be 48 at a power of 0.80 with a 0.05 alpha error (Zhang *et al.*, 2018)⁸

METHODOLOGY

MATERIALS AND ARMAMENTARIUM:

- Pre-treatment lateral cephalograms of orthodontic patients
- Post fixed functional therapy lateral cephalograms of orthodontic patients
- Dolphin imaging software version 11.95

INCLUSION CRITERIA:

1. Patients in the age group of 12-25 years
2. Patients who have an Skeletal maturity indicator (SMI) of 8 and above
3. Patients with Class II malocclusion
4. Pre and post-fixed functional therapy lateral cephalograms in which the desired landmarks could be identified and later be digitized will be used

EXCLUSION CRITERIA:

1. Patients with history of trauma, syndromes or deformity
2. Patients who had undergone previous maxillofacial surgery
3. Patients who have temporo-mandibular disorders

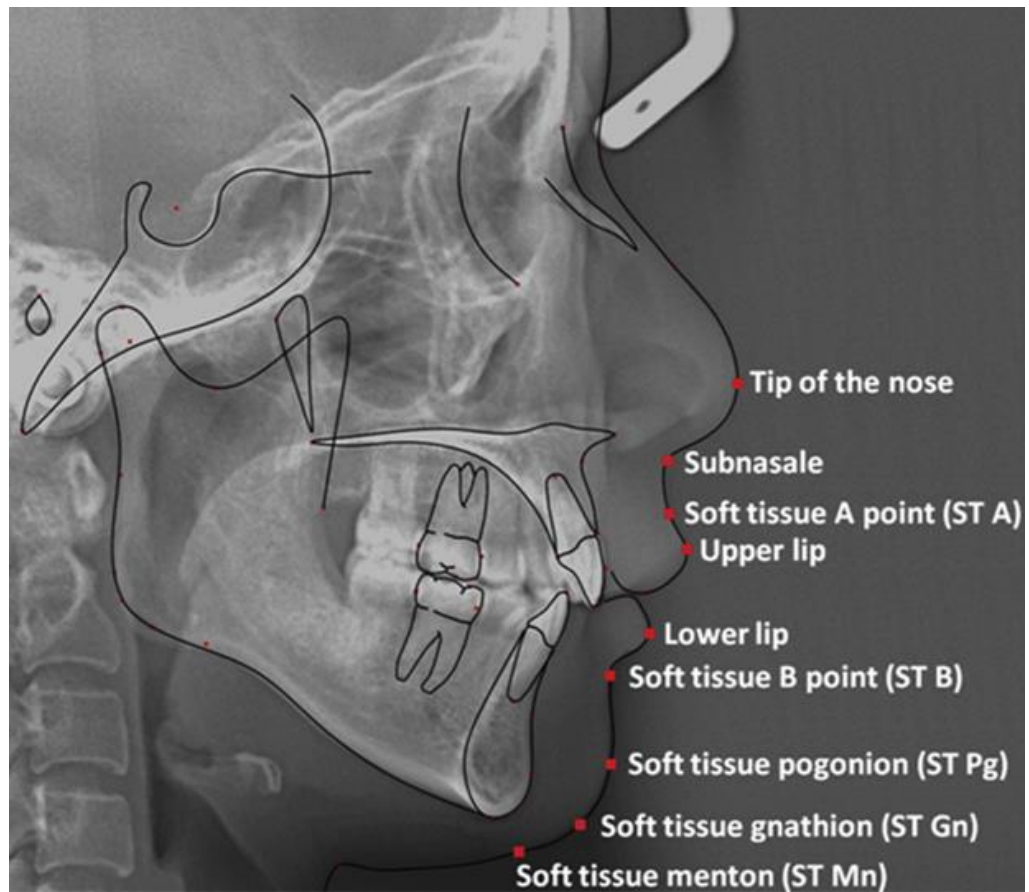


Figure 1: Landmarks of Holdaway Soft Tissue Analysis

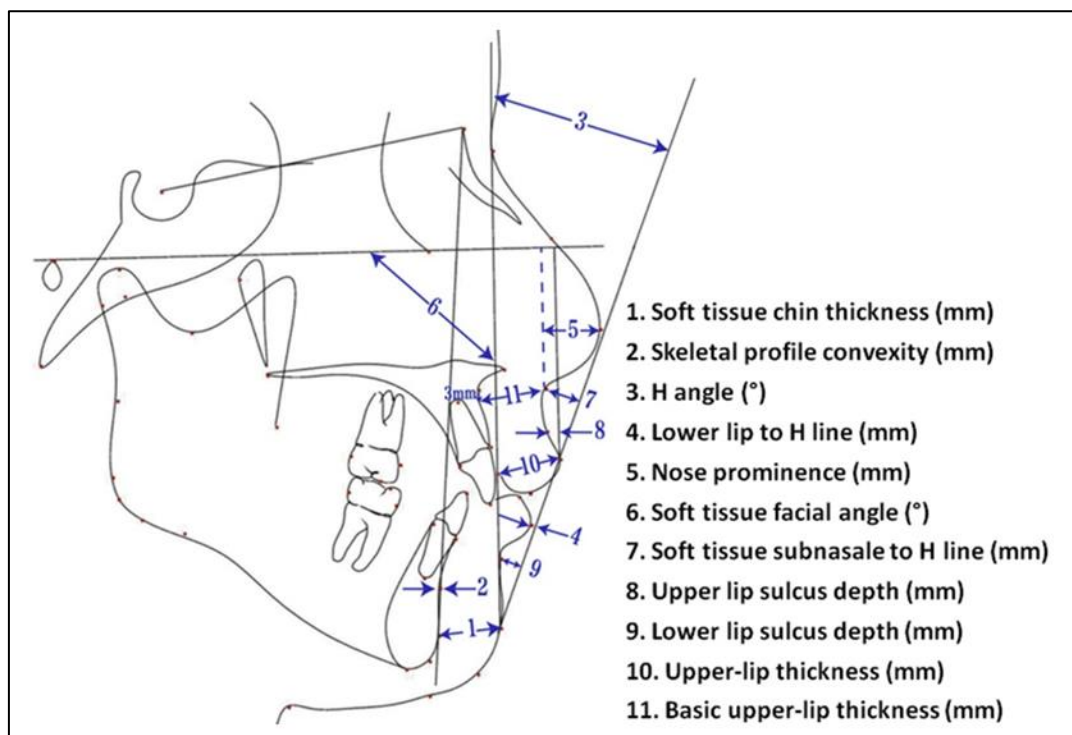
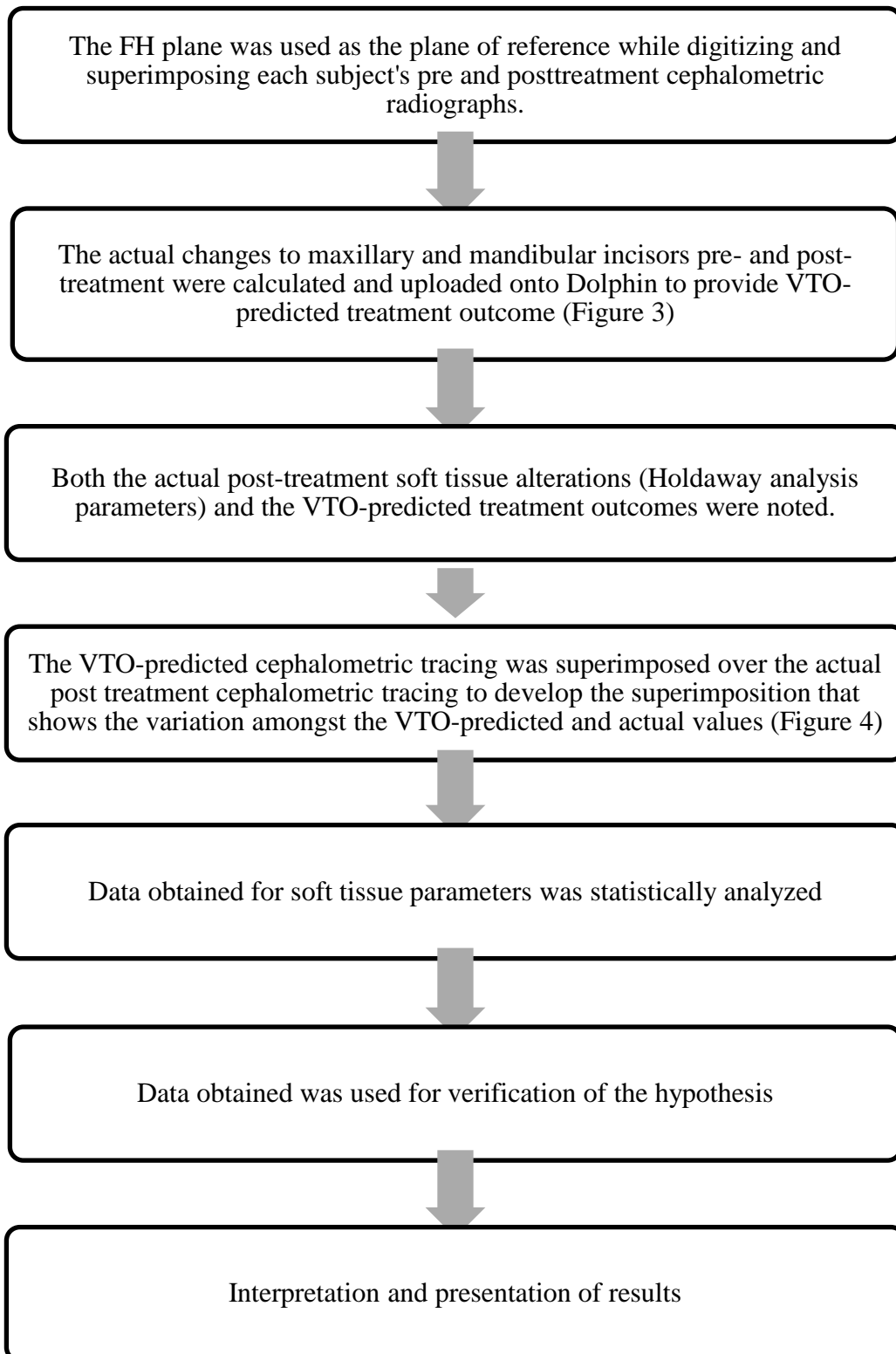


Figure 2: Parameters of Holdaway Soft Tissue Analysis

STEPS:



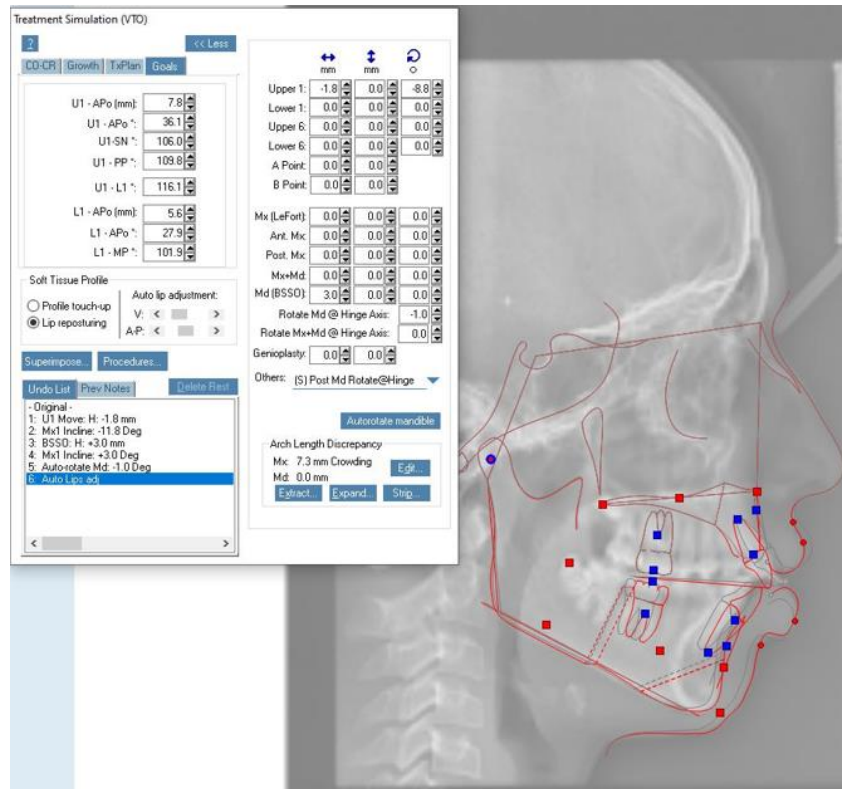


Figure 3: Actual hard tissue changes input into the Dolphin treatment simulation module to generate a VTO-predicted outcome

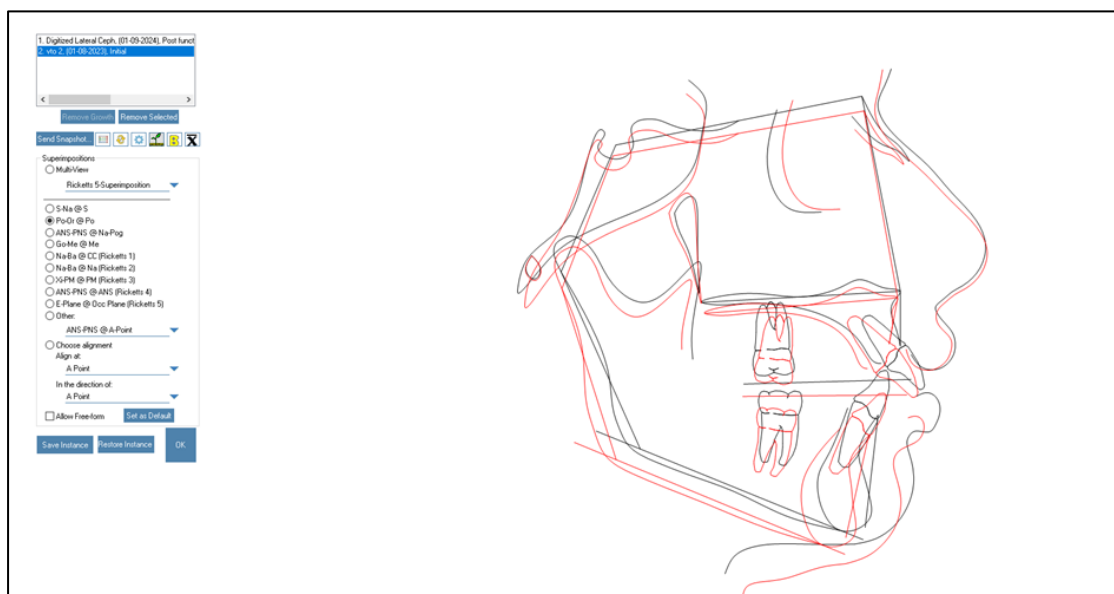


Figure 4: Cephalometric superimposition of the actual changes after treatment (black line) and the VTO predicted changes (red line) for calculating the predication errors.

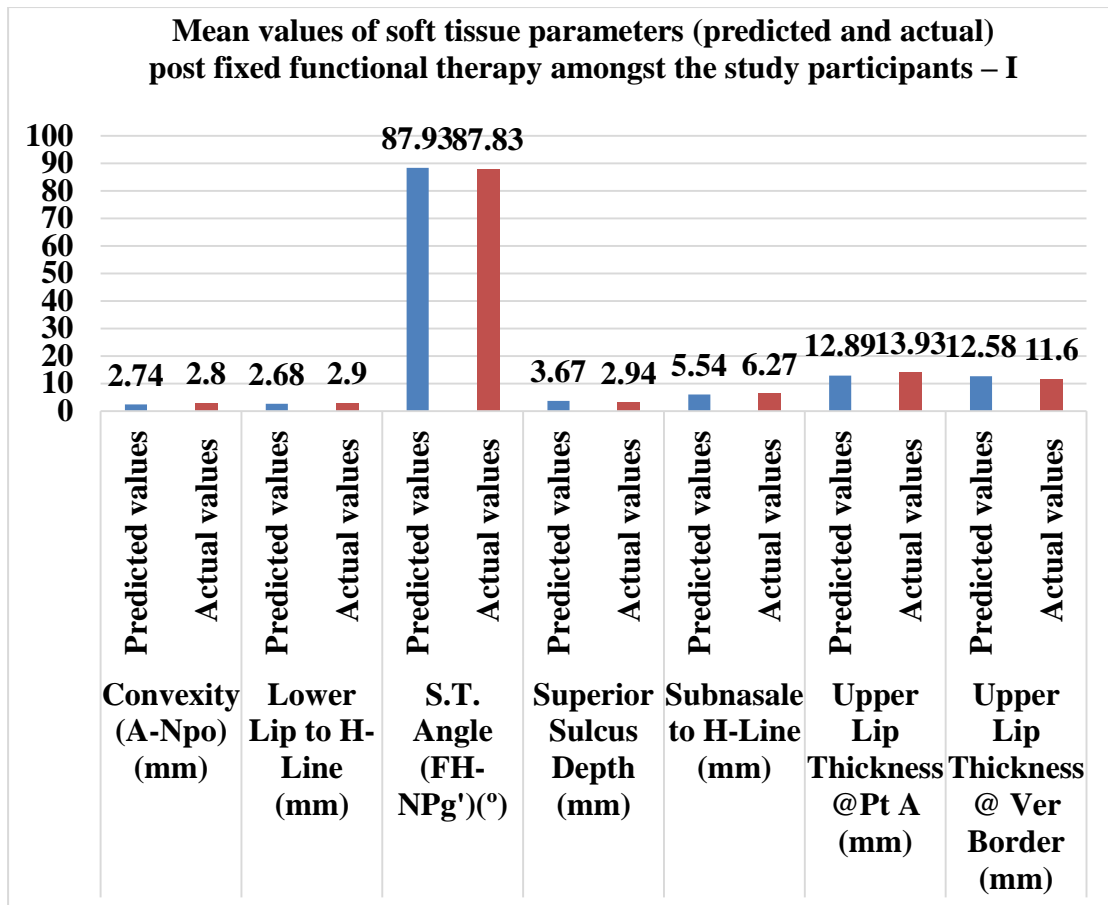
STATISTICAL ANALYSIS

- Data obtained was entered in Microsoft Excel 2020, and was analyzed using the IBM Corp. Released 2012, IBM SPSS® Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.
- The descriptive statistics was presented as mean \pm standard deviation for continuous variables.
- To compare the difference between the predicted and the actual treatment outcome of the same group, paired t-test/Wilcoxon's sign rank test was used.
- Statistical significance will be set at $p \leq 0.05$.

RESULTS

**Table 1 - Descriptive statistics of soft tissue parameters (predicted and actual)
post fixed functional therapy amongst the study participants – I**

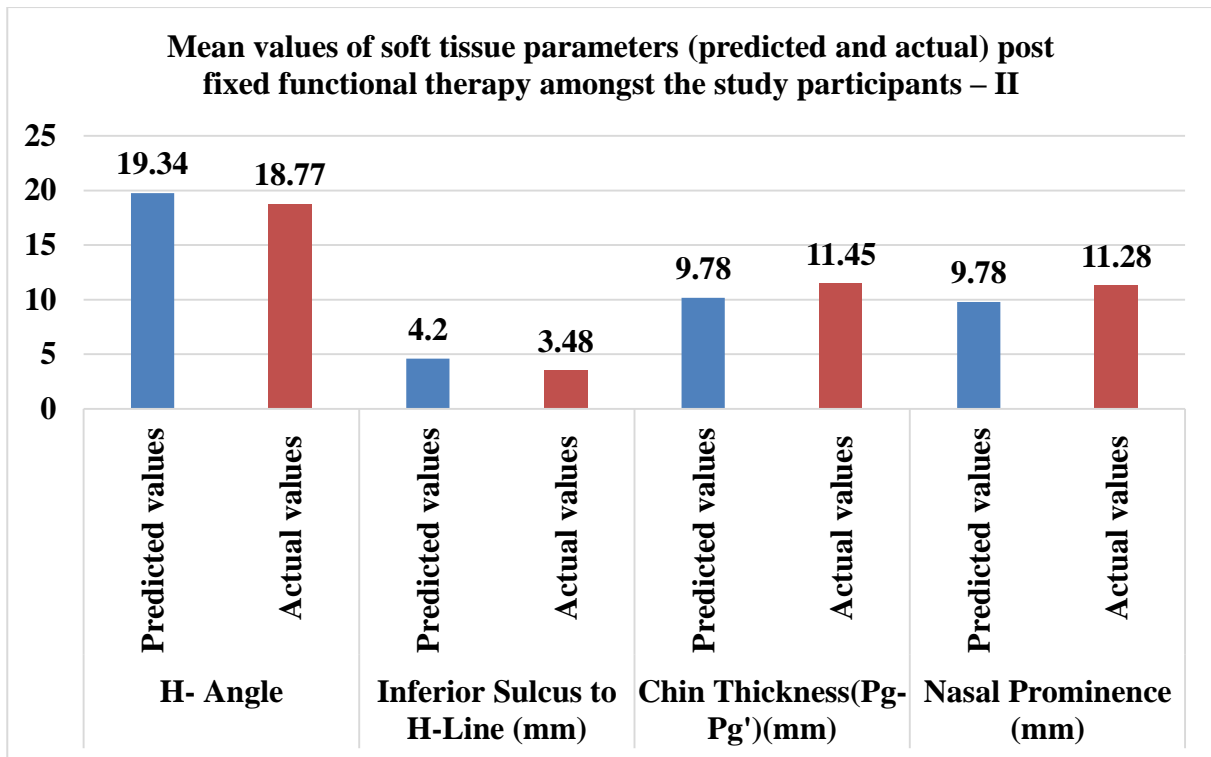
Parameter	Values	N	Minimum	Maximum	Mean	Std. Deviation
Convexity (A-Npo) (mm)	Predicted values	48	-1.74	7.22	2.74	2.24
	Actual values	48	-3.30	7.70	2.80	2.57
Lower Lip to H-Line (mm)	Predicted values	48	-0.68	5.24	2.28	1.48
	Actual values	48	-0.40	6.60	2.90	1.52
S.T. Angle (FH-NPg')(^o)	Predicted values	48	80.15	95.71	87.93	3.89
	Actual values	48	82.40	95.30	87.83	3.58
Superior Sulcus Depth (mm)	Predicted values	48	1.00	5.80	3.67	1.12
	Actual values	48	-0.10	6.00	2.94	1.61
Subnasale to H-Line (mm)	Predicted values	48	1.92	9.16	5.54	1.81
	Actual values	48	1.30	10.70	6.27	2.13
Upper Lip Thickness at Pt A (mm)	Predicted values	48	8.90	17.40	12.89	1.93
	Actual values	48	9.20	19.10	13.93	2.32
Upper Lip Thickness at Vermillion Border (mm)	Predicted values	48	8.90	15.50	12.58	1.58
	Actual values	48	8.40	16.30	11.60	1.93



Discrepancies were more evident in Superior Sulcus Depth and Upper Lip Thickness, suggesting that Dolphin software slightly over or underestimates soft tissue projections in certain facial zones.

**Table 2 - Descriptive statistics of soft tissue parameters (predicted and actual)
post fixed functional therapy amongst the study participants – II**

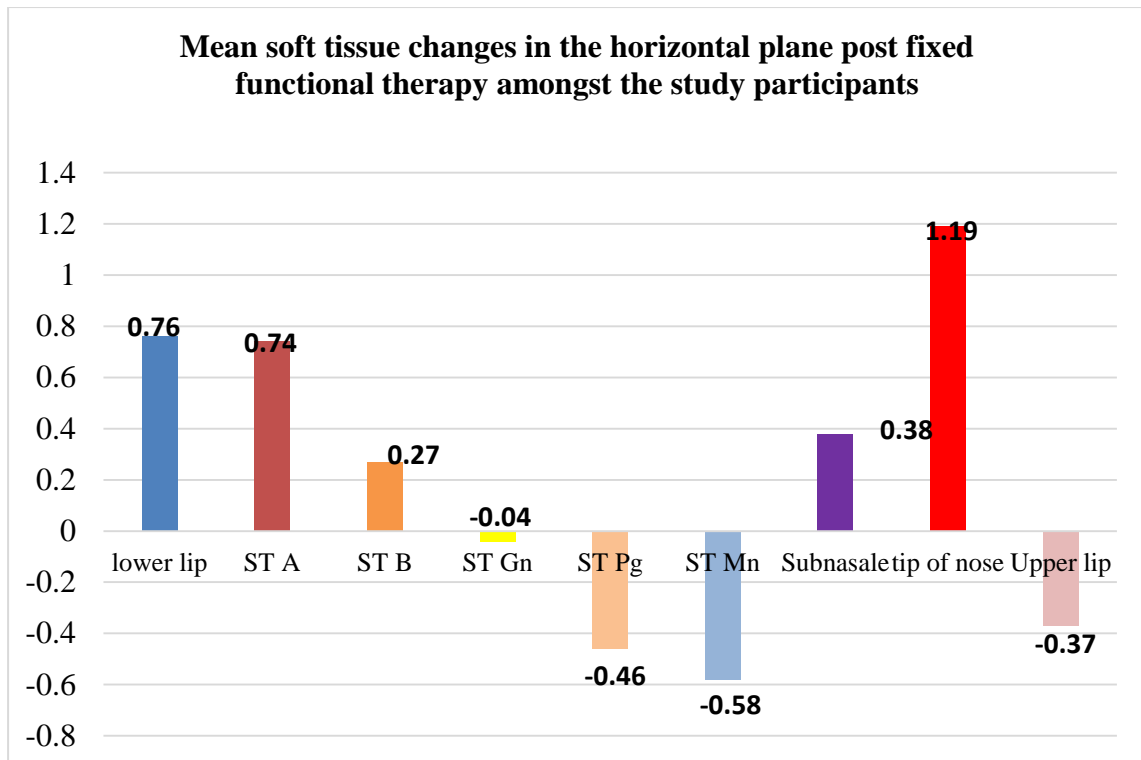
Parameter	Values	N	Minimum	Maximum	Mean	Std. Deviation
H- Angle	Predicted values	48	11.46	27.22	19.34	3.94
	Actual values	48	12.20	24.60	18.77	3.23
Inferior Sulcus to H-Line (mm)	Predicted values	48	0.42	7.8	4.20	1.89
	Actual values	48	-2.90	8.20	3.48	2.12
Chin Thickness(Pg-Pg')(mm)	Predicted values	48	5.56	13.99	9.78	2.11
	Actual values	48	5.10	14.90	11.45	2.10
Nasal Prominence (mm)	Predicted values	48	3.10	15.40	9.78	2.47
	Actual values	48	6.90	15.30	11.28	2.13



This table and graph demonstrated that while Dolphin software could closely predict values for H-Angle and Inferior Sulcus to H-Line, significant differences were noted in Chin Thickness and Nasal Prominence. The software tended to underestimate these structures, highlighting limitations in simulating post-treatment morphological changes in the lower facial regions. Accurate prediction in these areas may require refined algorithms or complementary clinical judgment.

Table 3 - Descriptive statistics of soft tissue changes in the horizontal plane post fixed functional therapy amongst the study participants

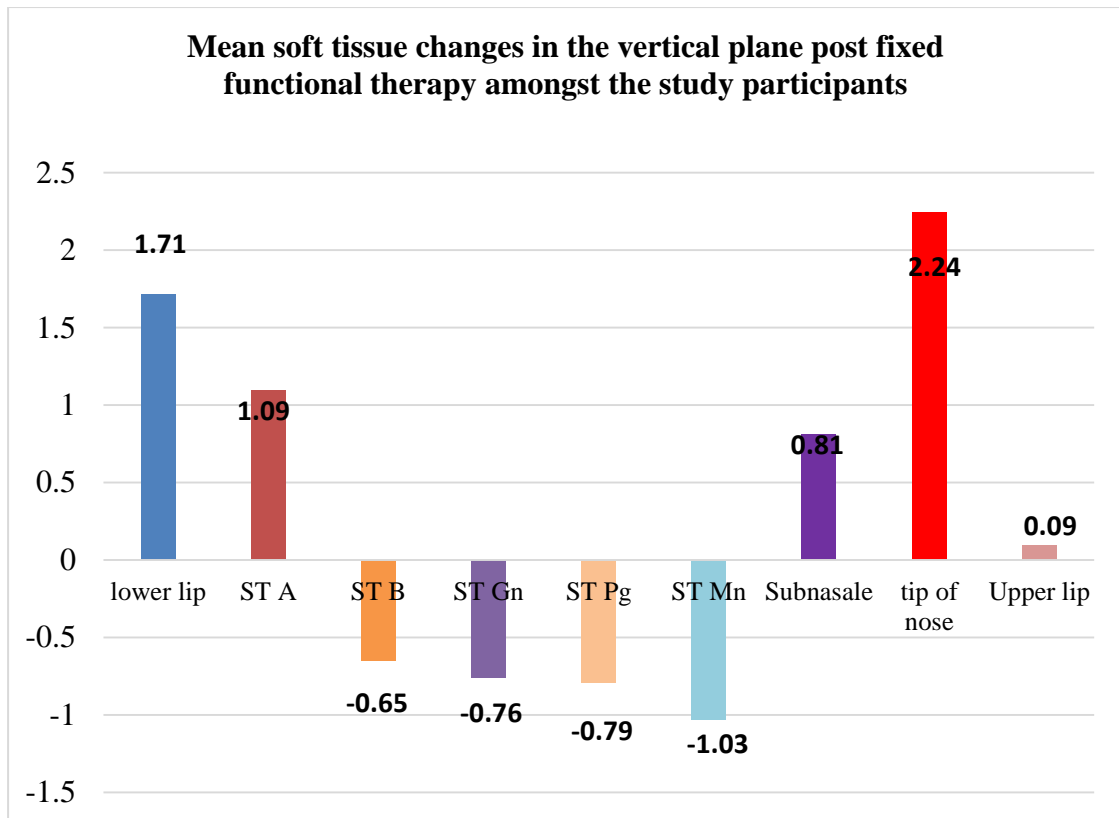
Parameter	N	Minimum	Maximum	Mean	Std. Deviation
lower lip	48	-4.86	6.38	0.76	2.81
ST A	48	-7.40	6.00	0.74	2.65
ST B	48	-6.11	6.65	0.27	3.19
ST Gn	48	-6.28	6.20	-0.04	3.12
ST Pg	48	-6.60	5.68	-0.46	3.07
ST Mn	48	-6.56	7.72	-0.58	3.57
Subnasale	48	-7.30	5.50	0.38	2.33
tip of nose	48	-6.90	6.70	1.19	2.61
Upper lip	48	-8.50	5.40	-0.37	3.24



Post functional therapy, horizontal soft tissue changes showed a wide range, with positive shifts in structures like the lower lip, tip of the nose, and subnasale, while regions such as ST Gn and ST Mn showed negative mean values. This suggests that soft tissue responses are region-specific, with maxillary structures showing minor movement or stability and movement of mandibular structures was undermined.

Table 4 - Descriptive statistics of soft tissue changes in the vertical plane post fixed functional therapy amongst the study participants

Parameter	N	Minimum	Maximum	Mean	Std. Deviation
lower lip	48	-3.9	7.41	1.71	2.91
ST A	48	-1.80	4.70	1.09	1.67
ST B	48	-5.31	4.01	-0.65	2.38
ST Gn	48	-5.86	4.34	-0.76	2.6
ST Pg	48	-6.18	4.60	-0.79	2.75
ST Mn	48	-6.54	4.48	-1.03	2.81
Subnasale	48	-3.09	4.71	0.81	1.99
tip of nose	48	-3.40	7.10	2.24	2.38
Upper lip	48	-3.70	4.60	0.09	2.25



Vertical soft tissue changes indicated significant upward or downward movements, particularly in the tip of the nose and lower lip regions. Positive vertical shifts were more prominent in nasal and upper lip regions, while negative values in ST B, ST Pg, and ST Mn indicated a downward movement post-treatment. These vertical alterations reflect the influence of functional therapy on facial height and lip posture.

Table 5 – Comparison between predicted and actual values of the soft tissue parameters post fixed functional therapy amongst the study participants

Parameter	Comparison Groups	Mean	Mean difference	Std. Error Mean	t value	p value
Convexity (A-Npo) (mm)	Predicted	2.7458	-0.0605	0.32275	-0.934	0.353
	Actual	2.8063		0.37235		
Lower Lip to H-Line (mm)	Predicted	2.6875	-0.2125	0.21304	-0.693	0.490
	Actual	2.9000		0.22037		
S.T. Angle (FH-NPg')(°)	Predicted	87.9333	0.0937	0.56106	0.647	0.519
	Actual	87.8396		0.51714		
Superior Sulcus Depth (mm)	Predicted	3.6792	0.73542	0.16188	2.590	0.011*
	Actual	2.9438		0.23325		
Subnasale to H-Line (mm)	Predicted	5.5438	-0.7312	0.26093	-0.820	0.414
	Actual	6.2750		0.30826		
Upper Lip Thickness at Pt A (mm)	Predicted	12.8958	-1.03958	0.27980	-2.377	0.020*
	Actual	13.9354		0.33606		
Upper Lip Thickness at Vermillion Border (mm)	Predicted	12.5896	0.98750	0.22869	2.737	0.007*
	Actual	11.6021		0.27898		
H- Angle	Predicted	19.3438	0.5667	0.56817	1.315	0.192
	Actual	18.7771		0.46624		
Inferior Sulcus to H-Line (mm)	Predicted	4.2021	0.7125	0.27181	2.715	0.008*
	Actual	3.4896		0.30671		

Chin Thickness (Pg-Pg')(mm)	Predicted	9.7833	-1.675	0.30328	-2.972	0.004*
	Actual	11.4583		0.30346		
Nasal Prominence (mm)	Predicted	9.7854	-1.49792	0.35677	-3.177	0.002*
	Actual	11.2833		0.30827		

*p value <0.05 statistically significant, <0.001 highly significant, <0.001 very highly significant

In our study, comparison between predicted and actual values of the soft tissue parameters post fixed functional therapy amongst the study participants was performed using Independent samples t-test.

This comparison showed statistically significant differences (p value <0.05) for all parameters; except Convexity (A-Npo) (mm), Lower Lip to H-Line (mm), S.T. Angle (FH-NPg')(°) , Subnasale to H-Line (mm) and H- Angle (p value >0.05).

DISCUSSION

It is common for orthodontists to be asked about possible changes in facial esthetics which may arise from a particular treatment regimen. As a result, it becomes important to guarantee precision in evaluating the outcomes of soft tissue alterations⁹. Such precision allows orthodontists to create the best treatment plans and gives them information about how their patients are going to look in the end, which improves patient comprehension and overall satisfaction.

However, a major concern is the disparity between the expected and actual soft tissue response following fixed functional therapy. Thus, this study evaluated the extent to which computerized software predicted soft tissue changes in patients after fixed functional therapy. When designing a successful therapy, the precision of automated software prediction is a crucial factor in evaluating and foreseeing a soft tissue profile following treatment.

Among the various soft tissue parameters of the Holdaway Analysis, this study found notable discrepancies between the expected values and the actual results. With the exception of Convexity (A-Npo) (mm), Lower Lip to H-Line (mm), S.T. Angle (FH-NPg')(°), Subnasale to H-Line (mm), and H-Angle (p value >0.05), every metric in this comparison showed statistically significant differences (p value <0.05).

While the characteristics in the chin area were predicted to be undermined both in sagittal and vertical, the landmarks in the lip region were predicted to have been overstated horizontally and underestimated vertically^{20,21} (see graphs 3 and 4). The landmarks surrounding the chin and lower lip had the most misguided predictions, whereas the upper lip had the most accurate.

The hard and soft tissue responses to orthognathic therapy were the main focus of earlier study on the Dolphin VTO's reliability and precision in estimating treatment outcomes^{10,23}. It became seeming that Dolphin VTO could predict changes in the hard tissue characteristics of S-N-B, S-N-A and facial-angle with an acceptable degree of accuracy^{11,24}. It is yet unknown how well Dolphin VTO predicts soft tissue alterations following orthodontic therapy.

Dolphin VTO did not exhibit a directional preference in the calculation, according to multiple investigations on orthognathic treatment^{12,26}. This is consistent with our observation that the distribution of soft tissue parameter overestimation and underestimation was comparable in both vertical and horizontal planes^{13,25}. Dolphin VTO was found to predict various parts of soft tissues with errors leaning toward specific directions in other studies. For example, one study discovered that the landmarks in the maxillary region were more likely to be undermined in the horizontal plane, whereas those in the mandibular region were more likely to be overstated^{14,27}.

Nearly all soft tissue characteristics were incorrectly forecasted in the vertical plane. Our finding that the distribution of overestimation and underestimating of soft tissue parameters was similar in both vertical and horizontal planes is in line with this. In other investigations, Dolphin VTO was found to predict certain soft tissue aspects with errors leading in particular directions. One study, for instance, discovered that the landmarks of the maxillary region were prone to be undermined in the antero-posterior plane, whereas the landmarks of the mandibular region were more likely to be overstated^{15,29}.

In the vertical plane, almost all of the soft tissue characteristics were poorly predicted. This is consistent with earlier research showing that the most wrongly predicted landmarks after orthodontic treatment were the chin and lips^{16,28}. In particular, landmarks around the chin and lower lip tended to be underestimated in the anteroposterior plane, while those near the upper lip were likely to be exaggerated.

Numerous factors such as perioral musculature, tonicity, soft tissue thickness, and underlying muscular attachments, may contribute to the incorrect prediction accuracy of soft tissue changes in the lip and chin areas. Furthermore, a person's BMI is linked to the unhinged characteristic of the thickness of soft tissue around the chin area. As a result, the prediction procedure did not incorporate these important variables, which might have jeopardized the overall precision of prognostic results¹⁶.

Although employing Dolphin Imaging software has improved clinicians' capability for predicting soft tissue profiles after fixed functional therapy, there are certain inconsistencies in treatment outcome prediction that are somewhat inaccurate in particular directions. Significant differences in the measurements were found in a number of investigations that contrasted the predictions made by the program with the actual results of treatment¹⁶.

This study showed that, across different study participants, mean variations between expected and actual post-fixed functional outcomes were contained within a range of no more than two millimeters. Although significant statistically, variations between simulated and genuine positions of certain landmarks were found, most of these differences were too minor to be considered clinically significant.

In order to predict soft tissue changes in orthodontic therapy with a clinically acceptable level of accuracy, Dolphin Imaging software may be a viable choice. The prediction by Dolphin VTO for the changes in soft tissue are established on a set ratio to mimic the changes following therapy; nevertheless, the literature remains ambiguous regarding the validity of this ratio.

Holdaway thought that the upper lip and maxillary incisors moved in a 1:1 ratio, while Dr. Ricketts thought that the ratio was 2:3. From 1:1.1 to 1:2.6, there is a wide range in the ratio of movement between skeletal and soft tissues. A multitude of factors, including tissue thickness and tension, gender, age, the measurement apparatus, might have affected soft tissue alterations in addition to hard tissue movement¹⁷.

LIMITATIONS OF THE STUDY

Firstly, the study was limited in its ability to measure changes in differences in the length of lip along a defined plane due to its usage of 2-D analysis.

Secondly, the Dolphin program generated an estimate based on a pre-set ratio of movement between hard and soft tissues to recreate changes during treatment. Nonetheless, variations that follow therapy are not just due to skeletal tissue movement; rather, a variety of other factors, such as thickness, strain, dentofacial structure and the tools utilized for measuring - influence soft tissue alterations. Therefore, in order to avoid irrational expectations and patient discontent, it is crucial to consider these aspects while making predictions.

Finally, this research was done retrospectively. Because of the various kinds and severity of skeletal and dental abnormalities, the participants were not entirely homogeneous (equal number of male and female participants were not included). If the SMI had been consistent throughout the sample. Better results might have been achieved with a larger sample size.

FUTURE SCOPE

Further research focusing on 3D construction using Cone Beam Computed Tomography and advanced 3D facial scanning technologies would be highly beneficial in enhancing soft tissue analysis. The integration of these technologies can greatly enhance the precision and comprehensiveness of craniofacial assessments.

By advancing this field of study, clinicians can gain a more precise and comprehensive insight into various treatment modalities, such as fixed functional appliance therapy, orthodontic treatments involving premolar extractions, and orthognathic surgical planning, ultimately contributing to better diagnosis, treatment outcomes, and patient care.

CONCLUSION

Dolphin Imaging software serves as a useful visual tool for predicting soft tissue changes following fixed functional therapy, though its accuracy varies across facial regions.

The software's predictions were most reliable for the upper lip, aligning closely with actual post-treatment outcomes. In contrast, greater discrepancies were observed in predictions for the lower lip and chin, warranting cautious interpretation. Additionally, predictions were more precise with respect to vertical dimension compared to horizontal.

While some variations among real and forecasted values were statistically significant, they were clinically negligible.

All things considered, if Dolphin VTO's limitations are acknowledged and taken into account when making therapeutic decisions, it can be a useful tool for orthodontic treatment planning as well as for improving patient comprehension and satisfaction.

SUMMARY

Improvement in facial esthetics is the most common motivation for seeking orthodontic treatment. To visually simulate and predict the orthodontic treatment outcomes, computerized profile and photograph prediction systems, such as Dolphin Imaging® can simulate the whole process of treatment by vivid, simple, and self-evident animations. The accuracy of computer-aided VTO prediction in soft tissue changes after orthodontic treatment using Dolphin Imaging software is still under debate.

This study hoped to identify the accuracy with which Dolphin imaging software's VTO simulation predicted soft tissue changes after fixed functional therapy in comparison to actual values.

These results showed statistically significant differences across all soft tissue parameters however the variations were clinically insignificant.

All things considered, if Dolphin VTO's limitations are acknowledged and taken into account when making therapeutic decisions, it can be a useful tool for orthodontic treatment planning as well as for improving patient comprehension and satisfaction.

By advancing this field of study, clinicians can gain a more precise and comprehensive insight into various treatment modalities, such as fixed functional appliance therapy, orthodontic treatments involving premolar extractions, and orthognathic surgical planning, ultimately contributing to better diagnosis, treatment outcomes, and patient care.

BIBLIOGRAPHY

1. Feldens CA, Nakamura EK, Tessarollo FR, Closs LQ. Desire for or thodontic treatment and associated factors among adolescents in Southern Brazil. *Angle Orthod* 2015;85:224-32.
2. Almrayati DM, Hajeer MY, Almusawi AOA, Jaber ST, Baba MO, Ajaj MA. Evaluation of the External Soft Tissue Changes Following the Correction of Class II Skeletal Malocclusion in the Adolescence Period Using Removable and Fixed Functional Appliances: A Systematic Review and Meta-Analysis. *Cureus*. 2024 Mar 27;16(3):e57070
3. Deva M, Sesham VM. Visual Treatment Objective: A Review. *Indian J Dent Adv*. 2018.
4. Tan SS, Ahmad S, Moles DR, Cunningham SJ. Picture archiving and communications systems: a study of reliability of orthodontic cephalometric analysis. *Eur J Orthod* 2011;33: 537-43.
5. Magro-Filho O, Magro-Ernica N, Queiroz TP, Aranega AM, Garcia IR Jr. Comparativestudyof2softwareprogramsforpredicting profile changes in Class III patients having double-jaw orthognathic surgery. *Am J Orthod Dentofacial Orthop* 2010;137: e451-5: discussion 452-3.
6. Omidkhoda, M., Heravi, F., Shahrestani, F., Noori, M. The Accuracy of Dolphin Software in Predicting Soft Tissue Changes after Orthognathic Surgery. *Iranian Journal of Orthodontics*, 2022; 17(2): 1-9
7. Elshebiny T, Morcos S, Mohammad A, Quereshy F, Valiathan M. Accuracy of Three-Dimensional Soft Tissue Prediction in Orthognathic Cases Using

- Dolphin Three-Dimensional Software. *J Craniofac Surg.* 2019 Mar/Apr;30(2):525-528.
8. Zhang X, Mei L, Yan X, Wei J, Li Y, Li H, Li Z, Zheng W, Li Y. Accuracy of computer-aided prediction in soft tissue changes after orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 2019 Dec;156(6):823-831.
 9. Nakornnoi T, Chanmanee P. Accuracy of Digital Imaging Software to Predict Soft Tissue Changes during Orthodontic Treatment. *J Imaging.* 2024 May 31;10(6):134.
 10. Soheilifar, S.; Soheilifar, S.; Afrasiabi, Z.; Soheilifar, S.; Tapak, L.; Naghdi, N. Prediction accuracy of Dolphin software for soft-tissue profile in Class I patients undergoing fixed orthodontic treatment. *J. World. Fed. Orthod.* **2022**, 11, 29–35
 11. Ahmad Akhouni MS, Shirani G, Arshad M, Heidar H, Sodagar A. Comparison of an imaging software and manual prediction of soft tissue changes after orthognathic surgery. *J Dent (Tehran).* 2012
 12. Gossett CB, Preston CB, Dunford R, Lampasso J. Prediction accuracy of computer-assisted surgical visual treatment objectives as compared with conventional visual treatment objectives. *J Oral Maxillofac Surg* 2005.
 13. Pektas ZO, Kircelli BH, Cilasun U, Uckan S. The accuracy of computer-assisted surgical planning in soft tissue prediction following orthognathic surgery. *Int J Med Robot.* 2007 Mar;3:64-71.
 14. Peterman RJ, Jiang S, Johe R, Mukherjee PM. Accuracy of Dolphin visual treatment objective (VTO) prediction software on Class III patients treated

with maxillary advancement and mandibular setback. *Prog Orthod* 2016;17:19.


15. Lu CH, Ko EW, Huang CS. The accuracy of video imaging prediction in soft tissue outcome after bimaxillary orthognathic surgery. *J Oral Maxillofac Surg* 2003;61:333-42.
16. Maniyar N, Prakash AT, Kumar HCK, Yavagal PC. Accuracy of Dolphin Imaging software in predicting soft tissue changes of Class II Division 1 incisor relationship treated by all first premolar extraction compared with post-treatment lateral cephalogram. *J World Fed Orthod*. 2024 Jun;13(3):128-135
17. Kolokitha OE, Chatzistavrou E. Factors influencing the accuracy of cephalometric prediction of soft tissue profile changes following orthognathic surgery. *J Maxillofac Oral Surg* 2012; 11:82-90.
18. Janson G, Castello Branco N, Aliaga-Del Castillo A, Henriques JFC. Soft tissue treatment changes with fixed functional appliances and with maxillary premolar extraction in Class II division 1 malocclusion patients. *Eur J Orthod*. 2017 Jul;40(2):cjsx053
19. Quintão C, Helena I, Brunharo VP, Menezes RC, Almeida MA. Soft tissue facial profile changes following functional appliance therapy. *Eur J Orthod*. 2006 Feb;28(1):35-41.
20. Güler ÖÇ, Malkoç S. Comparison of facial soft tissue changes after treatment with 3 different functional appliances. *Am J Orthod Dentofacial Orthop*. 2020 Oct;158(4):518-526.

21. Akan B, Veli İ. Evaluation of soft-tissue changes in young adults treated with the Forsus fatigue-resistant device. *Am J Orthod Dentofacial Orthop.* 2020 Apr;157(4):481-489.e2.
22. Varghese RM, Subramanian AK, Sreenivasagan S. Comparison of dentoskeletal changes in skeletal Class II cases using two different fixed functional appliances: Forsus Fatigue Resistant Device and Powerscope Class II Corrector – A clinical study. *J Int Oral Health.* 2021;13(3):271–6.
23. Nirayath KJ, Husain A. Assessment of visualized treatment objective and post-treatment outcome in skeletal Class II functional cases: A comparative study. *Asian J Dent Sci.* 2023;6(1):1–6.
24. Hussain S, Azeem M, Hamid WU. Relationship between positive clinical VTO and post-treatment soft tissue profile following phase I growth modification therapy. *Orthod J Nepal.* 2018;8(2):45–9.
25. Toepel-Sievers C, Fischer-Brandies H. Validity of the computer-assisted cephalometric growth prognosis VTO (Visual Treatment Objective) according to Ricketts. *J Orofac Orthop.* 1999;60(3):185-94.
26. Flores-Mir C, Major PW. A systematic review of cephalometric facial soft tissue changes with the Activator and Bionator appliances in Class II division 1 subjects. *Eur J Orthod.* 2006 Dec;28(6):586-93.
27. Yıldırım E, Karaçay Ş, Tekin D. Three-dimensional evaluation of soft tissue changes after functional therapy. *Int J Dent.* 2021;2021:9928101.
28. Almrayati DM, Hajeer M, Almusawi AOA, Jaber ST. Evaluation of the external soft tissue changes following the correction of Class II skeletal

malocclusion in the adolescence period using removable and fixed functional appliances: A systematic review and meta-analysis. *Cureus*. 2024;16(3):57070


29. Kaur GJ, Gandhi G, Khanna M, Loomba A. A cephalometric evaluation and comparison of skeletal, dentoalveolar, and soft tissue changes brought about by the Forsus Fatigue Resistant Device and PowerScope fixed functional appliance. *J Indian Orthod Soc*. 2021;56(4):370–6.

ANNEXURE --I: ETHICAL CLEARANCE CERTIFICATE



Research and Ethics Committee
KLE VK INSTITUTE OF DENTAL SCIENCES
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SI. No. : 1660


CERTIFICATE

This is to Certify that the synopsis titled


"Evaluation of the accuracy of Dolphin
Imaging Software in Predicting Soft Tissue Changes Post
Fixed functional Therapy - A Retrospective Observational Study
Submitted by

Dr. REG. NO. II0222004 P. G. Student /
Staff, Guided by _____ from Department of
Orthodontics and Dentofacial
Orthopedics has been critically evaluated by
committee members and granted ethical clearance to conduct the above
mentioned study

Date : 16/04/2025



Member Secretary
 Research and Ethical Committee
 KLEVK Institute of Dental Sciences
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ANNEXURE- II: MASTER CHART OF VTO- PREDICTED AND ACTUAL VALUES OF HOLDAWAY SOFT TISSUE ANALYSIS

	Convexity (A Npo) (mm)		Lower Lip to H-Line (mm)		S.T. Angle (FH-NPg)(°)		Superior Sulcus Depth (mm)		Subnasale to H-Line (mm)		Upper Lip Thickness @Pt A (mm)		Upper Lip Thickness @ Ver Border (mm)		H- Angle		Inferior Sulcus to H-Line (mm)		Chin Thickness(Pg)(mm)		Nasal Prominence (mm)	
	predicted	actual	predicted	actual	predicted	actual	predicted	actual	predicted	actual	predicted	actual	predicted	actual	predicted	actual	predicted	actual	predicted	actual	predicted	actual
dev	1.6	1.1	3	2.5	89.6	88.5	4.6	5.4	9	9.4	15.2	15.6	15.5	15.1	21	20.7	6	6	11.6	12.4	7.7	9.5
shagufta	3.1	4.7	2.7	3.7	90.3	88.4	3.2	2.1	5.9	4.5	17.4	13	13.4	12.8	23.2	20.6	5.3	3.4	11.9	12.8	12.3	13.9
umehani	0.1	0.1	4.3	3.7	88.9	88	4	2.8	5.9	3.8	13.6	12.8	13.6	12.8	17.8	16	6.2	2.9	8.6	8.5	8.6	10.4
guru	1.7	3.9	1.5	-0.4	89.5	88.2	5.8	6	9.7	10.1	14.6	12	14.5	15.7	19	23.5	6.5	5.9	12.8	13.2	5.4	7.3
nanappa	2.8	2.5	1.1	2	84.6	86.3	3.1	1.5	4.9	5.8	10.9	14.9	10.9	9.8	14.9	15.6	4.8	0.7	10.2	14.4	10.1	11.3
pritam	1.4	2	3.1	2.3	86.4	84.6	4.1	1.6	7.6	5.8	13.6	15.7	12.1	12.9	21.8	17.5	1.2	5.5	9.2	10.3	10.5	14.3
adarsh	5.2	-2.3	1.8	1	87.7	86.3	3.9	4.4	6.6	7.1	12	16.8	15	14.9	20.9	16.8	4.6	4.3	9.6	12.4	10.1	14.6
shifa	1.2	-1.4	1.5	2.4	80.8	83.8	3	1.7	5.1	8.2	13.8	18.6	9	8.4	15.2	21.9	3	3.1	8.8	10.7	12.4	9.4
sanjana T	0.5	1.5	0.6	1.2	92.1	95.3	3.9	3.7	7.3	5.1	14.2	11.7	8.9	11.3	14.6	13.3	7.1	5.7	12.2	12.5	6.5	8.5
minaz m	2.6	3.3	1.3	1.6	89.7	86.4	4.1	2.9	5.9	5.4	11.8	13.7	11.7	9.7	19.6	20.1	4.4	3.8	10.6	10.9	7.6	8.5
sachi	5.2	5.9	2.2	2.3	87.8	86.6	4.9	4.3	7.2	8.1	10.9	11.2	12	11.6	21.3	22.1	5.1	2.7	12	11.5	9	10.4
tanuja	2.6	3	1.8	2.2	81	83.6	1	1.6	3.8	3.6	11.6	11.2	10.3	13.9	15.1	14	3.1	4	8.5	13.9	15.4	15.3
rushada	6.4	5.6	3.4	3.6	80.1	85.3	2.7	2.3	7.9	9.1	14.4	16.9	12.2	12.4	24.9	24.2	4.3	6	12.8	14.6	9.5	10.4
sumit	1.6	1.1	2.5	4	90.3	88.5	5	4.9	6.9	7.4	10.7	13	10.8	12.3	19.6	23.8	4.6	4.7	7.2	7.7	5.9	6.9
prajwal	8.7	6.5	-0.5	1.6	85.5	86.8	2.9	3.3	4.3	4.9	11.3	11.5	12.9	12.4	20.8	20.1	5	4.4	12.2	11.6	12.3	11.5
meenaz	2.8	-3.3	4	1.8	86.8	93.5	4.8	13.2	4.2	5.8	17.4	17.3	14.5	13.4	20.5	19.6	4.5	5.4	11.5	12.1	8.3	7.8
venkatesh	-0.9	-0.6	0.29	1.4	88.6	91.7	2.3	2.9	1.8	5	15.2	14.7	14.2	12.4	13.8	15	8.7	5	11.5	11	13.9	11.7
yashoda	4.8	4.5	-4.7	5.4	89.1	90.3	5.4	4.5	7.4	6.4	10.3	11.3	11.7	11.6	22.8	19.1	3	2.6	7.4	10.6	6.7	7.9
shweta	5.8	2.6	1.4	2.8	79.1	85.2	2.8	-0.1	6.4	1.3	13.5	11.4	11.7	8.8	27.3	17.5	3.8	0.2	5.5	10.8	7.9	13.6
sanjana K	4.6	3.9	1.9	4.7	87	89.7	3.7	1.8	8.1	6.6	13.6	16.8	12.1	10.9	21.6	17.5	2.4	2.3	10.9	13.5	10	12.2
gangadhar	4.5	3.5	3.2	4.3	82.6	85.1	2.7	2.9	5	4.4	10	10.7	13.1	11.6	17.3	14.9	2.8	3.4	7.6	9.5	8.7	10.2
amit	5.6	4.1	-0.68	5.5	82.1	82.6	4.6	2	8.9	10.7	13.6	14.8	14.1	10.5	21.9	22.3	2.2	-2.9	11.6	8.9	9.1	12.3
swastik	4.3	1.7	5.24	4.9	82.8	82.5	2.9	1.8	4.9	6.3	10.5	14.6	13	9.2	17.4	18.5	1.6	0.3	8.2	7.2	12	12.2
sushrut	0.9	1.2	2.3	-0.1	90.7	92.4	3	2.5	5.9	3.8	13.6	12.6	12.8	10.2	17.3	12.2	5.1	5.4	10.6	12.7	8.1	10.9
shreyansh	5.9	4.8	3.8	4.6	90.8	88.2	3.1	4.9	5.7	6.2	8.9	16.5	10.2	12.4	20.6	19.6	4.7	3.3	11.4	13.5	10.0	9.8
devraj	-0.3	-0.6	3.1	1.5	88.7	85.3	2.2	3.0	6.3	5.9	13.7	14.8	11.0	11.1	22.7	18.2	3.1	5.6	9.1	8.8	9.5	14.0
vinayak	2.9	-0.7	1.9	3.2	88.9	93.0	2.5	2.9	5.7	7.0	14.1	9.2	14.5	11.3	21.1	18.6	8.1	1.8	5.5	12.2	3.1	11.7
rahal	4.2	6.8	2.1	3.5	91.8	90.7	2.9	5.5	3.3	8.0	15.9	14.6	12.2	9.6	27.2	21.3	5.2	5.9	9.3	8.7	11.7	13.6
anuradha	3.8	4.5	2.6	0.4	91.5	90.8	1.0	3.4	4.7	8.7	10.9	11.5	13.7	10.0	21.2	16.4	4.2	5.5	8.8	11.2	14.4	10.5
soumya	-4.2	5.2	1.8	3.3	91.1	84.2	-1.7	4.3	5.2	7.2	12.3	14.5	12.6	16.3	16.3	19.8	3.4	5.3	9.8	14.2	10.0	9.7
prathibha	3.2	6.3	1.9	4.0	89.4	84.6	5.0	2.4	6.3	3.3	11.6	13.8	13.4	9.7	20.4	24.6	2.4	8.2	11.0	8.3	12.1	10.7
pradnya	3.8	1.5	3.2	5.1	85.2	85.5	4.7	2.0	4.7	5.7	11.7	12.1	12.1	13.0	17.4	22.6	7.2	2.0	11.0	11.5	8.0	10.3
shobha	2.7	5.9	2.6	0.9	95.2	84.5	4.2	2.1	5.0	9.3	10.2	12.7	12.5	8.6	19.1	12.3	0.8	2.1	10.7	11.4	9.9	13.1
akshita	7.2	1.5	4.2	4.9	80.4	88.6	4.6	0.9	6.4	3.5	11.7	15.0	14.5	14.9	19.3	24.4	2.9	-0.1	9.9	11.9	9.3	9.7
rahima	4.6	2.4	3.3	3.0	83.1	86.5	6.6	3.6	3.4	6.2	12.3	12.0	10.9	11.7	15.8	19.6	1.7	5.3	14.2	14.9	9.4	8.0
preethi	1.5	0.1	2.8	1.5	84.9	92.5	2.9	4.7	4.2	6.4	8.9	13.9	14.1	10.3	16.1	21.6	7.8	3.3	8.7	13.5	11.7	11.3
chandrashekar	-3.4	4.5	0.8	2.0	86.5	92.1	4.6	3.7	2.6	7.5	13.2	11.4	13.2	12.1	14.8	18.4	5.1	5.8	8.8	9.8	7.3	12.3
prateek	2.8	1.9	3.4	4.1	89.8	82.4	3.6	-0.1	9.1	3.3	14.8	13.6	11.1	9.9	17.2	20.9	2.8	0.5	6.6	9.7	9.3	11.0
sahana	-0.9	5.9	4.8	3.0	91.5	94.2	5.9	0.6	2.6	5.4	10.7	14.7	12.9	8.6	12.2	12.9	3.4	3.5	10.9	11.3	10.4	13.8
vaishnavi	2.6	4.0	0.9	3.6	92.8	90.1	3.9	5.4	3.4	10.1	12.6	13.4	11.4	9.8	18.7	18.8	4.7	1.0	11.4	12.3	13.2	10.0
bhakti	1.2	0.9	3.1	2.2	93.2	85.7	4.2	0.7	1.9	9.2	14.7	19.1	10.5	11.2	25.9	17.7	7.0	3.0	8.7	13.3	9.6	12.9
snoha	2.9	3.9	2.6	2.4	92.5	82.9	2.3	3.4	5.7	9.2	14.8	15.0	12.8	11.4	19.2	21.2	0.4	2.7	9.9	13.3	8.2	14.2
shribhakti	2.3	4.1	3.2	2.3	91.9	94.5	4.6	2.8	5.2	5.5	13.1	17.0	12.8	10.5	24.3	18.0	2.6	4.2	6.2	10.8	11.4	14.0
shivani	1.8	1.8	2.1	3.6	93.5	84.4	5.7	5.6	4.1	3.3	12.9	13.2	13.4	12.0	21.2	18.1	4.7	2.6	9.5	13.3	7.8	14.6
aditya	1.3	3.3	2.4	4.2	86.0	90.5	2.7	5.0	3.4	5.7	13.5	14.8	15.4	12.0	20.2	15.7	4.3	-0.1	7.3	5.1	11.7	10.5
geeta	-1.7	5.5	3.2	3.1	88.1	93.0	3.3	1.2	5.6	3.9	15.7	9.5	14.6	13.9	14.8	15.1	3.8	3.5	8.5	11.7	14.0	12.5
supreet	6.5	7.7	2.6	6.6	88.5	84.5	4.0	0.1	7.1	7.0	11.3	17.2	13.0	9.3	11.4	20.1	2.6	4.2	10.2	12.8	8.2	10.3
aastha	4.0	-0.5	1.3	1.8	92.8	88.0	4.8	1.8	3.8	5.4	15.8	16.6	11.5	12.7	22.1	18.6	3.7	3.6	9.7	12.8	11.6	12.1

**ANNEXURE III – MASTER CHART FOR DIFFERENCE IN VTO-
PREDICTED AND ACTUAL VALUES IN THE HORIZONTAL PLANE**

all are relative distances from the predicted value									
	lower lip	ST A	ST B	ST Gn	ST Pg	ST Mn	Subnasale	tip of nose	Upper lip
dev	3.5	4.6	3.1	2.7	6.4	-3.9	4.3	6.7	4.8
shagufta	-5.4	-6.4	-6.4	-8.3	-4.9	2.8	-6.7	-6.3	-7.6
umehani	-8.2	-7.3	-6.2	-7.6	-7.3	-5.9	-5.8	-6.9	-6.8
guru	4.8	0.98	3	1.9	3.5	3.8	0.4	4.2	-2.4
nanappa	3.1	2.8	5.1	0.8	1.4	7.2	0.9	2.4	1.3
pritam	-3	-0.8	-3	-2.5	-0.92	-4.1	1.4	4.5	-0.7
adarsh	2.4	0.9	-2.8	-4.6	-1.7	-7.2	2.2	2.1	-1.6
shifa	2.8	5.2	3.5	1.7	1	-3.9	1.8	-0.2	2.4
sanjana T	-1.1	-1.8	-0.9	-0.4	-1.5	-1.9	-0.3	0	-2
minaz m	0.8	2.2	0	-0.4	-0.8	1	2.8	1.3	1.5
sachi	5.3	6	5.7	3	2.7	4.3	5.3	6.7	5.4
tanuja	5.2	3.8	4.4	5.7	5.1	4.1	3.7	3.9	4.5
rushada	1.7	1.8	-1.1	-0.1	0	-2.7	0.6	3.2	1
sumit	2.4	1.6	0.8	1.6	0.4	0.6	2.2	1.3	1.9
prajwal	1.7	-0.1	0.7	-1.8	0.8	-0.2	-0.9	-0.4	0.4
meenaz	-1.6	0.2	-0.8	0.6	0.4	2.2	-1.3	0.4	0.1
venkatesh	4.6	2.9	-1	6.4	1.9	4.8	2.5	3.6	2.8
yashoda	0.6	-0.7	-0.4	-3.3	-0.6	-3.6	-1.4	-0.2	-1.8
shweta	4.2	-4.2	7.2	4.1	5.1	6.5	-2.1	-1.9	-6.8
sanjana K	1.9	1.3	-0.1	-2.8	0.1	-5.3	0.4	1.8	-0.9
gangadhar	-0.4	-0.7	-2.4	-3.9	-1.6	-3.3	-0.7	0.8	-0.4
amit	4.5	2	9	1	-1.5	5.8	0.3	2.3	-0.2
swastik	-0.2	0.5	1.2	-0.1	-0.7	-2	-1	-0.4	-0.6
sushrut	3.7	1.9	-0.3	-4.6	-4.3	2.1	0.2	-0.8	-2.1
shreyansh	2.4	3.1	2.8	1.3	7	-1.9	3.5	4.2	3.2
devraj	-1.4	-2.6	-0.8	-2.1	-1.8	0	-1.6	-0.9	-3.8
vinayak	-2.4	-3.5	-1.8	-1.3	-1.7	-0.6	-0.3	-0.5	-8.5
rahul	4.8	0.7	3	1.2	4.2	2.9	0.2	3.5	-1.8
anuradha	2.7	2.5	5.1	0.6	0.6	5.2	1.1	2.4	0.7
soumya	-3	-0.3	-3	-2.2	-1.2	-3.7	0.6	0.3	-0.1
prathibha	2.1	0.9	-1.5	-2.5	-2.8	-3.2	0.1	2.1	-1
pradnya	2.4	4	0.9	1.7	1	-3.9	1.8	-0.2	3
shobha	-1.1	-1.8	-0.9	-0.4	-1.5	-1.9	-0.3	0	-2
akshita	0.6	2.2	0	-0.4	-0.8	1	2.8	1.3	1.5
rahima	2.8	3.2	1.6	3	2.7	1.5	2.3	3.4	2.6
preethi	3.1	3.6	2.1	2.5	1.7	4.1	3.2	3.9	2.3
chandrashekar	1.7	1.8	-1.1	-0.1	0	-2.7	0.6	3.2	1
prateek	2.4	1.6	0.8	1.6	0.4	0.6	2.2	1.3	1.9
sahana	1.3	-0.1	0.7	-1.8	0.8	-0.2	-0.9	-0.4	0.4
vaishnavi	-1.6	0.2	-0.8	0.6	0.4	2.2	-1.3	0.4	0.1
bhakti	2.4	2.9	-1	2.9	1.9	4.8	2.5	3.6	2.8
snoha	0.9	-0.7	-0.4	-3.3	-5.3	-3.6	-1.4	-0.2	-1.8
shribhakti	2.6	-1.5	2.4	2.3	3.1	1.9	-2.1	-1.9	-6.8
shivani	1.9	1.3	-0.1	-2.8	0.1	-5.3	0.4	1.8	-0.9
aditya	-0.4	-0.7	-2.4	-3.9	-1.6	-3.3	-0.7	0.8	-0.4
geeta	1.8	2	9	1	-1.5	1.4	0.3	2.3	-0.2
supreet	-0.2	0.7	3.2	-0.66	-1.4	-1.8	-0.65	-1.7	-3.5
aastha	1.6	1.5	-0.6	-4.6	-2.5	2.7	0.3	-2.9	-2.3

ANNEXURE IV – MASTER CHART FOR DIFFERENCE IN VTO-**PREDICTED AND ACTUAL VALUES IN THE VERTICAL PLANE**

	lower lip	ST A	ST B	ST Gn	ST Pg	ST Mn	Subnasale	tip of nose	Upper lip
dev	-2.3	-2.4	-3.6	-3.9	2.3	-3.1	-2.4	1.6	-1.53
shagufta	1.4	-0.6	-2.53	0.46	-1.8	-2.6	-1.4	-2.9	-2.57
umehani	1.6	3.2	-2.1	2.8	2	3.1	0.3	2.1	0.68
guru	3.8	1.8	3.6	3.1	4.4	1.2	1.4	3.5	2.4
nanappa	5.6	2.6	2.2	1.1	1.6	5.2	3.5	6.8	-0.3
pritam	3.4	3.6	2.2	-1.2	-1.9	-1.8	5.7	7.1	4.1
adarsh	7.2	1.4	-0.3	-3.2	-5.5	-2.4	1.7	4.1	-0.5
shifa	1.3	2.3	0.3	3.1	4.1	0.3	0.5	0.2	-2.7
sanjana T	5	2.7	-0.1	1.6	2.2	-1.1	3.6	4.6	2.68
minaz m	-1.1	2.7	-3.2	-2.7	-2.7	-3.5	2.7	4.5	0.7
sachi	-1.5	-1.8	-5.4	-6.7	-5.7	-5.4	-2.4	1.4	-3.4
tanuja	-0.2	-0.5	-1.1	-1.2	-0.9	-3.1	-0.5	0.2	0.4
rushada	1.6	1.9	1	-0.9	0.1	-2.2	2.6	5.8	1.53
sumit	-0.3	-0.1	1.3	-1.4	1.1	-3.4	1.6	3.8	0.2
prajwal	-1.9	2.4	0.2	-1.4	0	0.2	0.4	1.7	1.7
meenaz	2.4	2.3	0.1	-0.3	1.3	-0.1	2.4	1.4	1.4
venkatesh	5.8	2.9	-1	6.4	1.9	4.8	2.5	3.6	2.8
yashoda	3.4	-0.1	-1.6	-4.8	-2.3	-2.4	0.1	-0.7	0.8
shweta	7.8	-1.1	4.6	2.8	4	0.4	0.3	2.1	-2.9
sanjana K	2.9	2.3	1.3	-0.5	0.2	-3.7	6	6.4	4.6
gangadhar	2.1	2.8	-3.1	-2	-3.3	-2.3	3.4	1.7	3.9
amit	9	2.5	5.5	1.1	-3.4	-0.6	3.1	5.2	-2
swastik	0.2	-1.8	-1.1	-0.1	-1.4	-3	-1.9	-0.9	-3.7
sushrut	0	1.9	-0.3	-4.6	-4.3	-4.9	0.2	-0.8	-2.1
shreyansh	-1.2	0.3	-3.8	-2.6	-2.5	-3.1	-0.6	1.2	-1.8
devraj	0.8	-1.4	-2.9	0.8	-1.1	-4.1	-2.1	-2.8	1.85
vinayak	1	1.1	-1.9	2.3	1.7	2.8	0.4	2.3	3.26
rahul	2.3	0.9	3.1	2.5	3.1	0.8	1.1	3.2	1.5
anuradha	3.6	2.3	1.4	1.6	1.7	4.1	2.6	4.3	-0.1
soumya	2.4	3.9	1.6	-1.2	0.8	-1.5	4.4	3.6	1.84
prathibha	4.1	0.9	-0.3	-3.2	-3.2	-2.4	1.7	4.1	-0.5
pradnya	0	0.1	0.3	3.1	3.6	0.3	0.5	0.2	-2.7
shobha	5	2.7	-0.1	1.6	2.2	-1.1	3.6	4.6	2.18
akshita	-1.1	2.7	-3.2	-2.7	-2.7	-3.5	2.7	4.5	1.56
rahima	-1.5	-1.8	-3.7	-2.9	-3.5	-2.8	-1.6	1.4	-3.4
preethi	-0.2	-0.5	-1.1	-1.2	-0.9	-3.1	-0.5	0.2	0.4
chandrashekar	1.6	1.9	1	-0.9	0.1	-2.2	2.6	2.8	0.37
prateek	-0.3	-0.1	1.3	-1.4	1.1	-3.4	1.6	1.9	0.78
sahana	-1.9	2.4	0.2	-1.4	0	0.2	0.4	1.7	1.36
vaishnavi	2.4	2.3	0.1	-0.3	1.3	-0.1	2.4	1.4	1.4
bhakti	2.6	1.4	-1	3.6	1.9	2.7	1.3	3.8	2.46
snoha	3.4	-0.1	-1.6	-2.8	-2.3	-2.4	0.1	-0.7	0.27
shribhakti	7.8	-1.1	3.6	2.8	4	0.4	0.3	2.1	-2.36
shivani	2.9	2.3	1.3	-0.5	0.2	-3.7	2.7	3.2	1.9
aditya	2.1	2.8	-3.1	-2	-3.3	-2.3	1.8	1.7	1.37
geeta	9	2.5	2.3	1.1	-1.1	0.6	0.7	1.2	-2
supreet	0.2	-1.8	-1.1	-0.1	-1.4	-3	-1.9	-0.9	8.56
aastha	0	1.9	-0.3	-0.8	-1.8	-2.3	0.2	-0.8	-0.38