Original Research Article

Assessment of Visualized Treatment Objective and Post-Treatment Outcome in Skeletal Class II Functional Cases: A Comparative Study

Abstract

Objective

Predicting facial growth would be of great benefit in planning orthodontic treatment. Successful prediction requires specifying growth's magnitude, timing, and direction in a baseline or reference point context. This study aimed to analyze the accuracy of visual treatment objectives in predicting the treatment outcome for patients who had undergone Class II functional therapy. The objectives included comparing clinical and Dolphin visual treatment objectives to the post-treatment profile changes and predicting skeletal, dental, and soft tissue response.

Method

Pre-treatment and post-treatment photographs were utilized, including clinical VTO and Lateral cephalogram. The pre-treatment cephalogram and profile photographs were used to construct the Dolphin VTO image. The Dolphin VTO analysis was then compared with the post-treatment digitized cephalogram analysis to determine the accuracy of the VTO by comparing predetermined points on the VTO to the same points on the post-treatment cephalogram tracing.

Results

The Dolphin simulation software accurately predicted treatment outcomes for skeletal parameters except for lower anterior facial height. For dental parameters, the software inaccurately predicted the treatment outcomes for upper incisor proclination. Simulation software inaccurately predicted the H angle, LL to E line, and LL to H Line for soft tissue parameters.

Conclusion

The outcome of this study concluded that the skeletal, dental, and soft tissue prediction was acceptable using the Dolphin visual treatment objective prediction software.

Keywords

Dolphins; Incisor; Cephalometry; Prognosis

Introduction

The Visualized treatment objective (VTO) can depict the most probable growth pattern and anticipated treatment influences. Computer-generated image prediction is suitable for patient education and communication. However, efforts are still needed to improve the accuracy and reliability of the prediction program. The soft tissue profile, excluding the nose, tends to remain relatively stable in its degree of convexity. In this respect, soft tissue changes are not analogous to those exhibited by the skeletal profile. [(1)] The change in soft tissue profile is directly related to the hard tissue changes; it is essential that the system accurately predict hard tissue changes. For the Dolphin System to be clinically useful, the prediction of the hard tissue must be accurate. [(2)]

Predicting the results of orthodontic treatment is valuable because it helps orthodontists make treatment plans and provides a preview of the final appearance of patients. Prediction improves patients' understanding and satisfaction. [(3)]

This study aimed to analyze the accuracy of VTO in predicting the treatment outcome for patients who had undergone Class II functional therapy. The objectives included comparing clinical and Dolphin VTO to the post-treatment profile changes and predicting skeletal, dental, and soft tissue response.

Methods

This was a retrospective study. Materials required for the study included records (photographs and lateral cephalogram) of patients who had undergone fixed and removable functional appliance therapy and Dolphin Imaging software version 11.0.03.37 (Patterson Dental Supply, St. Paul, MN) (Figure 1).

The study was initiated after obtaining ethical clearance from Yenepoya University Ethical Committee 2. Pre-treatment and post-treatment records of 16 patients were obtained from the age group of 11- 16 years who had undergone removable and fixed functional appliance therapy. Pre-treatment and post-treatment photographs were utilized, including clinical VTO and Lateral cephalogram (Figure 2). The pre-treatment cephalogram and profile photographs were used to construct the Dolphin VTO image (Figure 3).

The Dolphin VTO analysis (Figure 4) was then compared with the post-treatment digitized cephalogram analysis to determine the accuracy of the VTO by comparing predetermined points on the VTO to the same points on the post-treatment cephalogram tracing (Figure 5). The inclusion criteria included patients for whom complete pre- and post-treatment records are available, patients in the age range of 11-16 years at the start of treatment, patients with overjet equal to or more than 7mm, and patients with satisfactory dental health. The exclusion criteria included non-extraction cases, orthognathic surgery cases and patients with cleft lip and palate defects or craniofacial dysmorphology, patients with syndromes, presenting facial paralysis, patients with gross facial asymmetry and deformities, and patients not willing to participate.

The parameters used in this study were [4],

Skeletal Parameters

i. SNA- The angle between lines SN and NA
ii. SNB- The angle between lines SN and NB
iii. ANB- The angle between lines AN and NB
iv. LAFH- Lower anterior facial height
v. SN-OP- The angulation of the cranial base (SN) with the occlusal plane
vi. SN-MP- The angulation of the cranial base (SN) with the mandibular plane

Dental Parameters

i. U1-NA- The distance between the tip of the upper incisor and a line from nasion to point A
ii. L1-NB- The distance between the tip of the lower incisor and a line from nasion to point B
iii. L1-MP- The angulation between the long axis of the lower incisor and the mandibular plane
iv. L1-A Pog- The angulation between the long axis of the lower incisor and point A to the Pogonion line

Soft Tissue Parameters

i. H Angle- The angle formed between a line tangent to the chin and upper lip with the NB line
ii. UL-E Line- Upper lip to E-line
iii. LL- H Line- Lower lip to H-line
iv. Superior sulcus depth- The distance between the upper lip sulcus and a perpendicular line drawn from the vermilion to the Frankfort plane
v. Inferior sulcus depth- Inferior sulcus to H-line

vi. Chin thickness- The distance between hard tissue and soft tissue Pogonion

Statistical Analysis

Simple Random sampling was followed. At a 5% level of significance and 4.05 standard deviation with a 2% margin of error, the total sample size is 16. Data were tabulated using Microsoft Excel (Version 14.1.0, Redmond, WA), entered into SPSS software (Version 21.0, Chicago, IL), and subsequently analyzed. One sample t-test will be used.

Results

Skeletal parameters for removable functional appliances showed no statistically significant difference (Table 2). This suggests that the Dolphin simulation values were accurate in predicting treatment outcomes. Skeletal parameters for fixed functional appliances showed statistically significant differences for LAFH (Table 3). The Dolphin simulation did not accurately predict the lower anterior facial height.

Dental parameters for removable functional appliances showed no statistically significant differences (Table 4). The software accurately predicted the treatment outcomes. Dental parameters for fixed functional appliances showed statistically significant differences for U1 to NA (Table 5). The Dolphin simulation software did not accurately predict the treatment outcomes for upper incisor proclination.

Soft tissue parameters for removable functional appliances showed statistically significant differences for the H angle (Table 6). This suggests that the software did not accurately predict the treatment outcome for upper lip prominence. Soft tissue parameters for fixed functional appliances showed statistically significant differences for the H angle, LL to E line, and LL to H Line. This suggests that the software did not accurately predict the treatment outcome for soft tissue parameters.

Discussion

VTO is a visual plan to forecast the expected growth of the patient and anticipated influences of treatment to establish individual objectives for that patient (Ricketts). [5] The present study compared clinical VTO to computer-generated VTO and post-treatment profile changes to discriminate between skeletal, dental, and soft tissue-based prediction methods. Results for both prediction methods revealed that VTOs were reasonably accurate for some variables but inaccurate for others.

The differences between VTO and posttreatment means of the SNA and SNB measurements were not considered clinical significance because the differences were less than 1°. Statistical evaluation of dental measurements revealed a difference in the position of the mandibular incisor, suggesting a poor prediction. Dolphin VTO was accurate in predicting post-treatment soft tissue convexity. There was a reasonably accurate prediction of anteroposterior lip positions related to the nose and soft tissue chin and excellent accuracy in predicting the chin thickness. Confounders such as weight fluctuation, alterations in head posture, and facial muscle activity impede the interpretation of genuine soft-tissue displacement. [6]

Data for males and females were pooled; therefore, differences between sexes cannot be determined from this study. This is a limitation since neither manual nor computer prediction methods allow sex differences in growth to be expressed in the VTOs. In his study, Sample LB [7] stated that manual and computer VTO methods accurately predict skeletal changes that occurred during treatment. However, both ways were only moderately successful in forecasting dental and soft tissue alterations during treatment. Only slight differences were seen between manual and computer VTO methods, with the computer slightly more accurate with the soft tissue prediction.

For several factors, the Dolphin VTO prediction of soft tissue changes after orthodontic treatment in patients with bimaxillary protrusion may deviate significantly from the actual treatment result. The prediction was more accurate in the vertical direction than the horizontal direction, with soft tissue A predicting the most accurately and soft tissue in the chin region predicting the least accurately. [8]

Dolphin Imaging Software can be used to calculate postsurgical cephalometric readings with the same precision as traditional methods. Dolphin Imaging Software version 10 should be re-evaluated for software faults that could lead to clinically significant miscalculations, such as compensating for radiographic magnification when using linear measures. It must also focus on mandibular autorotation and lip posture. This software allows you to modify your lips and soft tissue vertically and horizontally. It should, however, take into account soft tissue tension and muscle strain. [9]

Dolphin assures accurate soft tissue behavior prediction in the sagittal plane. Most reliably and with the least projected error was the nasal tip. The sub nasale, upper lip, and sub nasale and pogonion were the areas that were least accurate. [10]

Advantages of VTO include the establishment of specific treatment goals, formulation of a particular plan of treatment to reach treatment goals, assistance in determining if the ideal treatment result is attainable orthodontically or surgically, help in making mid-treatment corrections, enhancing communication between patients and clinicians, allowing quantification of proposed movements to reduce the difficulties in planning a facial response to different directions, and allowing rapid comparisons of other treatment options before arriving at a final treatment plan. [11]

Conclusion

1. The skeletal, dental, and soft tissue parameters correlated well when Dolphin VTO was compared with the post-treatment tracings.
2. Dolphin simulation satisfactorily predicted treatment outcomes compared with clinical VTO and post-treatment profiles.

Ethical Approval:

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

Consent

As per international standard or university standard, patient(s) written consent has been collected and preserved by the author(s).

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Figures cited

Figure 1. Dolphin software

Figure 2. Uploading photographs and radiographs

Figure 3. Digitizing the landmarks

Figure 4. 2D VTO Simulation

Figure 5. Comparison of Pre-treatment, Clinical VTO, Dolphin VTO, and Post-treatment profile changes.

Table 1. Skeletal parameters for removable functional appliance

		Mean	**SD**	**P-value**
SNA	Dolphin simulation value	82.06	7.32	0.47
	Post-treatment value	81.03	4.83	
SNB	Dolphin simulation value	76.78	5.21	0.41
	Post-treatment value	77.43	4.24	
ANB	Dolphin simulation value	5.17	3.70	0.20
	Post-treatment value	3.60	1.64	
LAFH	Dolphin simulation value	27.66	15.31	0.55
	Post-treatment value	31.67	21.63	
SN-OP	Dolphin simulation value	16.43	6.06	0.76
	Post-treatment value	16.81	3.80	
SN-MP	Dolphin simulation value	32.32	8.02	0.09
	Post-treatment value	33.77	8.90	

$p<0.05$ is considered significant.

Table 2. Skeletal parameters for fixed functional appliance

		Mean	SD	P-value
SNA	Dolphin simulation value	82.52	3.58	0.19
	Post-treatment value	83.32	4.23	
SNB	Dolphin simulation value	79.03	3.58	0.91
	Post-treatment value	78.95	3.29	
ANB	Dolphin simulation value	3.45	2.67	0.28
	Post-treatment value	4.38	1.47	
LAFH	Dolphin simulation value	58.02	3.42	0.004
	Post-treatment value	61.40	4.12	
SN-OP	Dolphin simulation value	14.67	4.91	0.76
	Post-treatment value	15.13	5.88	
SN-MP	Dolphin simulation value	29.87	5.25	0.51
	Post-treatment value	29.31	6.36	

$p<0.05$ is considered significant.

Table 3. Dental parameters for removable functional appliance

		Mean	N	S. D	P-value
U1-NA (°)	Dolphin simulation value	31.78	8	10.33	0.09
	Post-treatment value	25.97	8	3.64	
U1-NA (mm)	Dolphin simulation value	3.86	8	3.88	0.41
	Post-treatment value	2.96	8	2.41	
L1-NB (°)	Dolphin simulation value	27.65	8	5.22	0.13
	Post-treatment value	32.08	8	7.58	
L1-NB (mm)	Dolphin simulation value	5.95	8	3.27	0.12
	Post-treatment value	3.56	8	2.39	
L1-MP (°)	Dolphin simulation value	98.45	8	6.80	0.34
	Post-treatment value	101.12	8	12.39	
L1-A Pog (mm)	Dolphin simulation value	3.36	8	2.35	0.18
	Post-treatment value	1.98	8	1.37	

$p<0.05$ is considered significant.

Table 4. Dental parameters for fixed functional appliance

		Mean	**N**	**S. D**	**P-value**
U1-NA (°)	Dolphin simulation value	33.8	8	4.53	0.01
	Post-treatment value	28.2	8	4.29	
U1-NA (mm)	Dolphin simulation value	7.02	8	2.86	0.12
	Post-treatment value	5.52	8	1.50	
L1-NB (°)	Dolphin simulation value	30.80	8	5.32	0.12
	Post-treatment value	34.17	8	4.66	
L1-NB (mm)	Dolphin simulation value	7.48	8	.70	0.88
	Post-treatment value	7.41	8	1.05	
L1-MP (°)	Dolphin simulation value	104.06	8	7.61	0.25
	Post-treatment value	105.52	8	6.51	
L1-A Pog (mm)	Dolphin simulation value	5.67	8	1.29	0.09
	Post-treatment value	4.61	8	1.36	

$p<0.05$ is considered significant.

Table 5. Soft tissue parameters for removable functional appliance

		Mean	N	S. D	P value
H angle	Dolphin simulation value	15.5	8	3.16	0.03
	Post-treatment value	17.3	8	2.72	
UL-E plane	Dolphin simulation value	-1.5	8	1.79	0.9
	Post-treatment value	-1.5	8	2.18	
LL-E plane	Dolphin simulation value	.40	8	.78	0.5
	Post-treatment value	.10	8	1.14	
LL-H line	Dolphin simulation value	1.05	8	1.04	0.8
	Post-treatment value	1.0	8	.59	
Superior sulcus	Dolphin simulation value	1.1	8	.53	0.2
	Post-treatment value	.98	8	.63	
Inferior sulcus	Dolphin simulation value	1.4	8	.74	0.7
	Post-treatment value	1.6	8	1.74	
Chin thickness	Dolphin simulation value	4.2	8	2.83	0.5
	Post-treatment value	3.9	8	2.36	

$p<0.05$ is considered significant.

Table 6. Soft tissue parameters for fixed functional appliance

		Mean	N	S. D	P value
H angle	Dolphin simulation value	15.3	8	4.43	0.02
	Post-treatment value	18.0	8	4.30	
UL-E plane	Dolphin simulation value	-1.9	8	1.98	0.347
	Post-treatment value	-1.4	8	2.05	
LL-E plane	Dolphin simulation value	-.6	8	2.11	0.006
	Post-treatment value	1.4	8	1.94	
LL-H line	Dolphin simulation value	.5	8	1.45	0.002
	Post-treatment value	2.5	8	.97	
Superior sulcus	Dolphin simulation value	2.51	8	.51	0.38
	Post-treatment value	2.87	8	1.40	
Inferior sulcus	Dolphin simulation value	4.35	8	2.09	0.78
	Post-treatment value	4.22	8	1.90	
Chin thickness	Dolphin simulation value	10.00	8	2.73	0.84
	Post-treatment value	10.2	8	2.99	

$p<0.05$ is considered significant.

Figure 1. Dolphin software

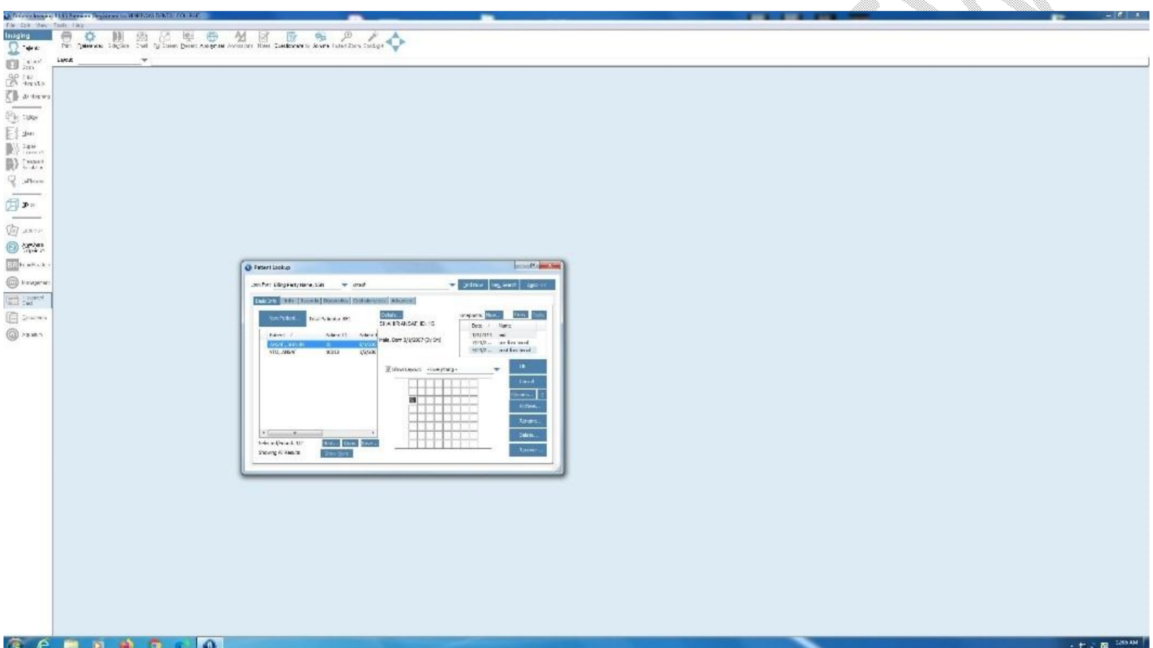

Figure 2. Uploading photographs and radiographs

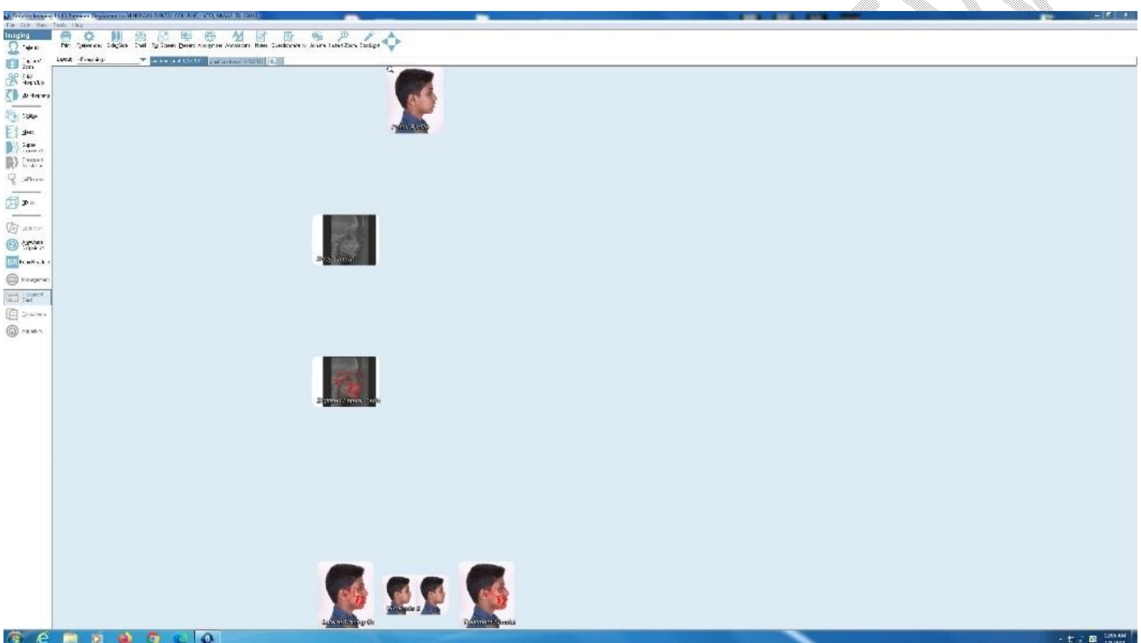

Figure 3. Digitizing the landmarks

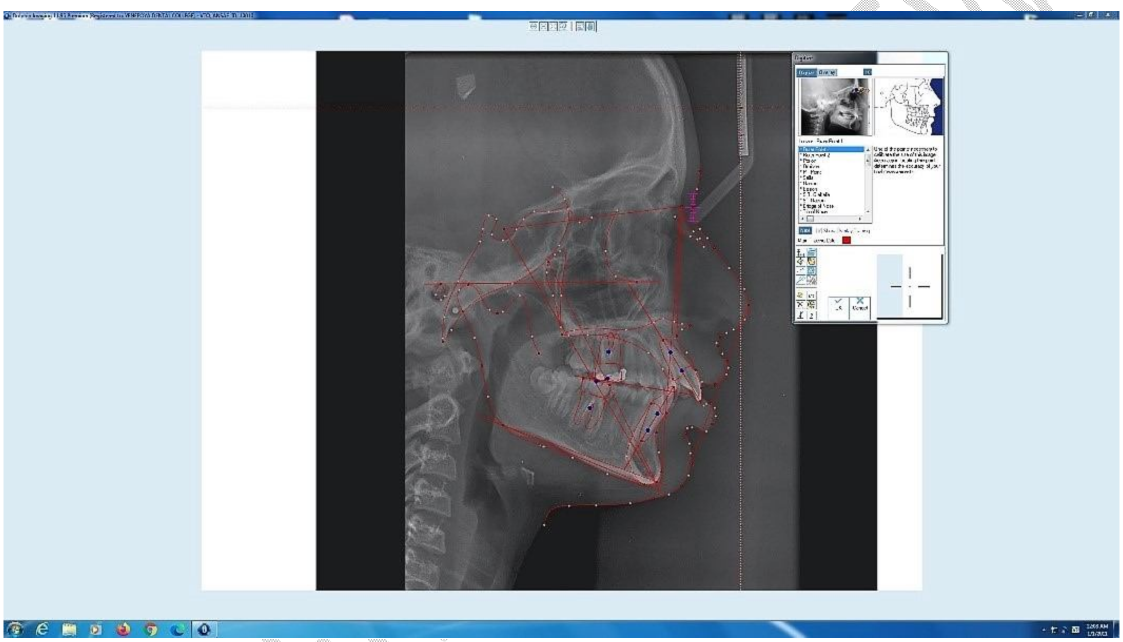

Figure 4. 2D VTO Simulation

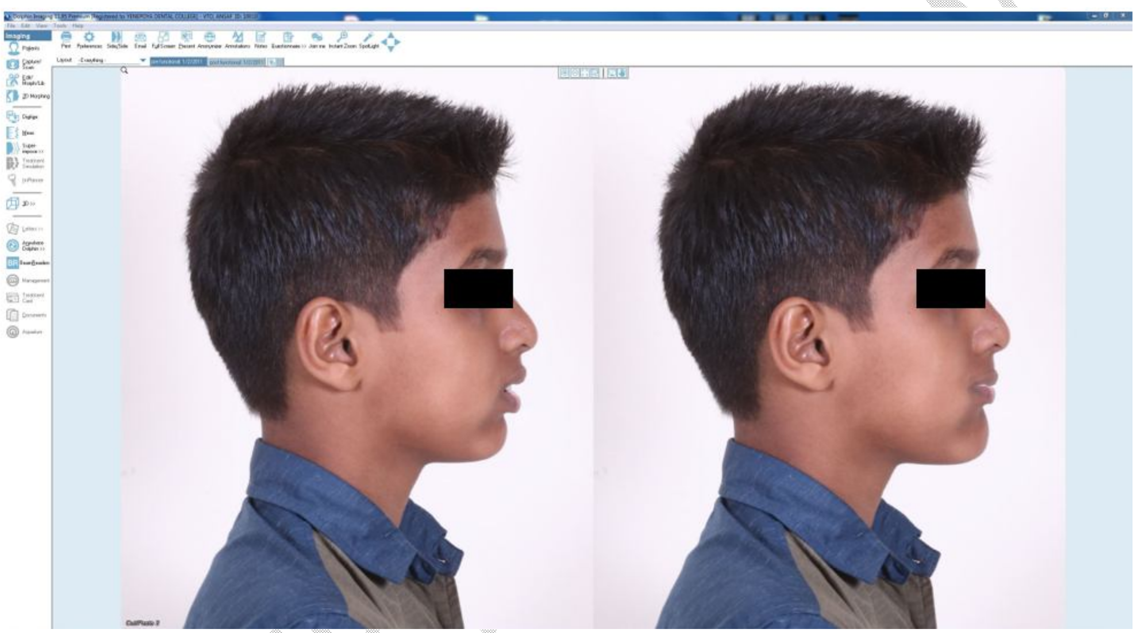

Figure 5. Comparison of Pre-treatment, Clinical VTO, Dolphin VTO and Post-treatment profile changes.