Research Square

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Study on soft tissue symmetry of patients with cleft lip and palate based on stereoscopic photography

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Abstract

Objective: In this retrospective study, three-dimensional photography (3dMD) was used to evaluate the facial soft tissue symmetry of unilateral cleft lip with alveolar cleft (UCLA) and unilateral complete cleft lip and palate (UCLP). The differences between the cleft side and non-cleft side were compared, and symmetrical mirror image analysis was performed.

Methods: The study comprised 39 patients including 21 patients with UCLA and 18 patients with UCLP. All subjects were scanned by facial stereo photogrammetry to obtain facial soft tissue data and construct a three-dimensional digital model. The characteristic line distance in the three-dimensional direction of facial soft tissue was selected, and 3dMD Vultus software was used to measure the three-dimensional digital model of the maxillofacial soft tissue. The data were statistically analyzed with SPSS 23.0. The measurement indices of bilateral facial symmetry in each group were tested by paired t-test. One patient was selected from each of the two groups for symmetrical mirror image analysis to evaluate the distribution and severity of asymmetry.

Results: There were significant differences in nostril, nasal alar and upper lip measurement indices between the two sides in both patient groups. These included the base of the nostril width (Sbal-Sni), nasal alar projection length (Ac-Prn), depth of midface (T-Sn) and all of the lip indices in both UCLA and UCLP groups. The nasal lateral length (En-Ac) was different in the UCLA group whereas the axial length of the nostril (Sbal-C) was different in the UCLP group. According to the mirror image analysis, the facial asymmetry of UCLA patients was identified principally in the ala, nostril and cheilion which was considered as mild asymmetry. Patients with UCLP showed severe asymmetry, including the entire midface.

Conclusion: Patients in both study groups continued to show facial soft tissue deformity in three-dimensional evaluation in prepuberty. It was principally manifested, but not limited to, the nasolabial area. The range of asymmetry in patients with UCLP was wider and the degree of asymmetry was greater than in patients with UCLA. The facial malformation of patients in both groups would still require additional improvement with subsequent treatment.

Introduction

Cleft lip and palate (CLP) is a common congenital deformity in the oral and maxillofacial region, often characterized by morphological deformities of both facial soft and hard tissues. As such, these CLP patients have different facial appearances from their normal peers, and one of their chief complaints is to improve their appearance. These improvements clearly necessitate the involvement of orthodontists. Treatment plans of these patients should incorporate the most appropriate methods to treat their appearance, function and psychology at every stage of their growth and development. Therefore, an accurate evaluation of both soft and hard tissues constitutes the foundation for the diagnosis and design of orthodontic treatment and nasolabial repair.

Faces are not completely symmetrical. A large number of studies have confirmed that normal people have slight facial asymmetry[1−2], often found in the lower part of the face. Mild facial asymmetry is usually difficult to detect and does not affect facial beauty[3]. However, severe or pathological maxillofacial asymmetry affects the structure and function of teeth, soft tissue and jaw, which markedly compromises facial aesthetics that can even lead to serious social and psychological problems.

The symmetry of the nose has a profound effect on the appearance. Previous studies have determined that the nose of patients with CLP was usually asymmetric. The bridge of the nose was collapsed, the tip of the nose was deformed and tended to deviate to the unaffected side, and the width of the cleft side of the nose was increased[4−5]. Sagittal underdevelopment of the maxilla was typically the main cause of poor facial pattern. Related studies have shown that the potential for forward growth of the maxilla in patients with CLP was reduced due to tissue defects. Due to the presence of fissures, the direction and continuity of muscle fibers such as buccal palatal muscles and perioral muscle groups were interrupted, which led to distorted muscle tension. In addition, the growth of the maxilla was limited by iatrogenic contracture of lip and palate scar tissue[6−7].

Orthodontics and surgery are frequently used to improve facial deformities, but there is no consensus on the criteria of objective treatment evaluation. The methods for evaluation have been divided into qualitative and quantitative aspects; quantitative evaluation has been able to make up for deficiencies of objective qualitative evaluation. Optimal treatment of patients with CLP requires a high degree of accuracy. As noted, quantitative data obtained by measurement and analysis have been more advantageous, and the formulation of a treatment plan and subsequent outcome evaluation has been more accurate and less subjective. Clinicians have been able to understand the growth and treatment changes of patients through longitudinal evaluation of cranio-maxillofacial morphology[8−9]. Comparison of craniofacial morphology between patients with CLP and normal people has provided more accurate and reliable theoretical support for a treatment plan[10−11].

The traditional orthodontic diagnostic methods have over emphasized cephalometric measurement and analysis of hard tissue, while largely ignoring coordinated changes of soft tissues. To maximize the orthodontic appearance, a harmonious consideration of soft tissues should be undertaken with the initial treatment plan. Previously, clinical treatment planning methods commonly utilized direct measurement, two-dimensional photography, and various X-rays, all of which have limitations. More recently, three-dimensional photography (3dMD) has been widely used in maxillofacial soft tissue analysis. The advantages of 3dMD are many: noninvasive, low dose radiation, rapid imaging, highly precise and accurate quantitative measurements, reproducible, can be employed on children. It can transform a solid model into a digital model, which provides considerable convenience and cost savings for the storage and management of medical records. Additionally, the digitization of model images is also beneficial to clinical measurement analysis and comparative research. The error of manual measurement is reduced[12].

With the improvement of prenatal diagnosis technology, the proportion of patients with complete cleft lip and palate has gradually decreased, while the proportion of patients with relatively mild cleft lip and palate (such as alveolar cleft and cryptocleft) has gradually increased. Because of this shift to less severe deformities, we focused our study on the facial development and soft tissue morphology of two common kinds of less severe cleft lip and palate patients, UCLP and UCLA.

Material And Methods

Sample

Patients with cleft lip and palate were recruited from the Department of Orthodontics and Department of cleft lip and palate of Tianjin Stomatological Hospital from 2017 to 2019. All patients signed an informed consent form to assist in completing the experiment. The study included 21 cases of unilateral cleft lip with alveolar cleft (UCLA) and 18 cases of unilateral complete cleft lip and palate (UCLP). All CLP patients were between 8 to 14 years old. The patients had no systemic or other hereditary diseases and were diagnosed as non-syndromic cleft lip and palate. They had no history of orthodontic or orthognathic treatment, maxillofacial trauma, jaw disease or temporomandibular joint disease. Cleft lip and cleft palate repairs were performed in infancy, and bone grafting and secondary repairs of alveolar clefts were not performed.

Methods

The study protocol was approved by the ethics review board of Tianjin Stomatological Hospital. We have obtained written informed consent from all study participants. All of the procedures were performed in accordance with the Declaration of Helsinki and relevant policies in China. Written informed consent was obtained from all subjects and/or their legal guardian(for minor participants). All patients were photographed with three-dimensional camera equipment 3dMDface system (3dMD, LLC, Atlanta, GA, USA). Shooting methods: (1) photographs were carried out under standard office lighting conditions; (2) patients were positioned in the sitting position, body upright, maintaining a natural head position, chin slightly raised to obtain maximum facial exposure, eyes looking straight ahead, upper and lower teeth touching, lips naturally closed, facial muscles relaxed; (3) face and neck accessories were removed, both ears exposed, with full exposure from the hairline down to the thyroid cartilage; (4) patients faced the center of the 3dMD facial 3D camera system, about 1 meter from the cameras on both sides. After confirmation that the image was complete and the patients had no micro-expression after the shooting, the image was exported. All images were taken by the same photographer and the photography system was calibrated daily. To reduce the fixed point error of the image and ensure the consistency and accuracy of soft tissue landmarks, a fixed point on the subject's 3D image was made every two weeks, measured three times in total, and the average of the three measurements was used as the final measurement.

Image processing: the three-dimensional facial image data of subjects in this study were imported into 3dMD Vultus ®software (3dMD Vultus ®software version 2.3.0.2) for measurement and analysis. To facilitate statistical analysis, the images of patients with cleft lip and palate on the right side were preprocessed, then flipped along the vertical axis to appear as a left side cleft; therefore, all images of the study appeared to be located on the left.

Facial soft tissue landmarks and measurement indices: selected points with strong characteristics, easy identification and high repeatability were selected, as reported by Alpagan[13](Fig. 1, Table 1). There were 17 linear measurement indices (Fig. 2, Table 2) selected to study facial soft tissue symmetry.

Table 1
Facial soft tissue measurement landmarks

Landmark	Abbreviation	Definition
Tragion	TL(1),TR(2)	The intersection of the superior edge and the leading edge of the tragus
Endocanthion	EnL(3),EnR(4)	Located at the inner commissure of the eye fissure
Exocanthion	ExL(5),ExR(6)	Located at the outer commissure of the eye fissure
Nasion	N’(7)	Point in the midline of the nasal root identical to hard tissue nasion
Pronasale	Prn(8)	Most protruded point of the apex of the nose
Subnasale	Sn(9)	Midpoint of maximum concavity where the upper lip skin meets the columella base
Menton	Me(10)	The lowest median point on the lower border of the mandible
Subalare	SbalL(11), SbalR(12)	The point at the lower limit of each alar base, where the alar base disappears into the skin of the upper lip
Alare curvature	AcL(13), AcR(14)	Most lateral point in the curved baseline of each ala
Columellar root point	SniL(15), SniR(16)	The intersection of the nasal columella and the nasal base
Columellar high point	CL(17), CR(18)	The highest point at the intersection of the nasal columella and the medial edge of the nostril.
Nostril outer edge midpoint	AliL(19), ALiR(20)	The corresponding point of the mid-point of the alar wing process on the inside of the ala
Cheilion	ChL(21), ChR(22)	Point located at each labial commissure
Christa philtri	CphL(23), CphR(24)	Point on each elevated margin of upper lip at the junction of the vermilion line of the upper lip and the white roll line

Table 2
Measurement index of facial soft tissue symmetry

Region	Linear index	Definition
Upper part of face	Ex-En	Eye width
	En-N’	Distance from the inner canthus to the nasal root point
Nose	Sbal-Sni	the base of the nostril width
	Sbal-C	the axial length of nostril
	Sni-Ali	Nostril width
	En-Ac	Nasal lateral length
	Ac-Prn	Nasal alar projection length
	Sni-C	Nasal columella height
Lip	Ch-Ac	The distance from the cheilion to the most lateral point of nose ala
	Cph-Sn	Distance from the subnasale to the philtri point
	Cph-Sbal	Distance from the philtri to the subalare point
	Sbal-Ch	Distance from the cheilion to the subalare point
Depth of face	T-N’	Depth of upper part of face
	T-Sn	Depth of middle part of face
	T-Me’	Depth of lower part of face
	T-Ex	Depth of lateral canthus-tragus
	T-Ch	Depth of cheilion-tragus

Statistical analysis

The statistical software (SPSS Inc, Chicago, USA) of SPSS 23.0 was used to analyze the data. The measured data of each group were tested for normality, and the data on both sides of the face in each group were compared by paired t-test, the test level $\alpha = 0.05$, the difference was statistically significant($P < 0.05$).

Symmetrical mirror image analysis of facial soft tissue

A patient was randomly selected from both the UCLA and UCLP groups. The 3D facial images were imported into Geomagic qualify software in wrp format. The 3D image was processed to remove the ear and neck images to prevent interference before the mirror image analysis. Image processing was divided into four steps. 1.Establish a median sagittal plane. The horizontal base plane was the plane passing through the bilateral external canthus and the nasion point. The median sagittal plane passed through the midpoint of the line of the bilateral medial canthus and perpendicular to the horizontal base plane. 2. The original 3D image was horizontally flipped 180 degrees around the median sagittal plane, so that the images on the left and right sides overlapped. 3. Registration of overlapping images: the relatively stable frontal region was used as a reference. The frontal region was matched to the maximum extent by the Geomagic qualify software to generate the best overlapping images. The image was a deviation analysis chart. 4. The asymmetry of the corresponding points on both sides of the face was shown according to the deviation analysis chart. If the two sides were completely symmetrical, the distance difference was 0. If the two sides were asymmetrical, different colors were shown on the deviation analysis chart according to the size and direction of the difference. The distribution and severity of asymmetry were judged by observing the color of each part in the deviation analysis chart. The degree of asymmetry was defined by the distance difference of the deviation analysis chart: 1. The distance difference was defined as symmetrical if the difference ranged from 0-2mm; 2. The distance difference was defined as slightly asymmetrical with a difference range of 2-4mm; 3. The distance difference was defined as severely asymmetrical with a difference range of 4-6mm.

Results

The results are shown in Table 3 and Table 4. The measurements of UCLA patients demonstrated no significant difference in the measurement indices of the upper part of face between the two sides ($P > 0.05$). Nasal measurements showed that the width of the base of the nostril (Sbal-Sni) and the lateral length of the nose (En-Ac) on the fissure side were larger than those on the non-fissure side. The nasal alar projection length (Ac-Prn) on the fissure side was smaller than that on the non-fissure side. The difference between the two sides was statistically significant ($P < 0.05$). There were significant differences in all lip measurement indices between the two sides ($P < 0.05$). The midfacial depth(T-Sn) of the fissure side was smaller than that of the non-fissure side, which was statistically significant ($P < 0.05$).

Table 3
Results of the facial soft tissue symmetry in patients with UCLA

Region	Measurements	Fissure side(n = 21)	Non-fissure side(n = 21)	T	*P*
		Mean ± SD	Mean ± SD		
Upper part of face	Ex-En	23.20 ± 1.82	23.24 ± 1.73	-0.300	0.767
	En-N’	22.69 ± 1.55	22.76 ± 1.57	-0.718	0.481
Nose	Sbal-Sni	9.34 ± 1.29	7.92 ± 1.38	5.176	**0.000***
	Sbal-C	10.88 ± 1.61	10.87 ± 1.34	0.060	0.952
	Sni-Ali	10.56 ± 1.59	9.95 ± 1.29	1.840	0.081
	En-Ac	41.90 ± 2.81	40.63 ± 2.52	4.299	**0.000***
	Ac-Prn	24.60 ± 2.05	26.88 ± 2.11	-9.211	**0.000***
	Sni-C	4.53 ± 0.94	4.42 ± 0.82	0.780	0.444
Lip	Ch-Ac	25.55 ± 2.48	26.63 ± 2.55	-5.081	**0.000***
	Cph-Sn	14.58 ± 2.19	13.15 ± 2.52	2.694	**0.014***
	Cph-Sbal	13.60 ± 3.00	16.09 ± 3.00	-6.993	**0.000***
	Sbal-Ch	25.38 ± 2.89	26.11 ± 2.69	-2.527	**0.020***
Face depth	T-N	115.7 ± 5.37	115.5 ± 5.24	-0.852	0.404
	T-Sn	119.5 ± 5.78	121.1 ± 5.64	-4.096	**0.001***
	T-Me'	136.6 ± 7.85	136.9 ± 7.30	0.527	0.604
	T-Ex	81.44 ± 4.82	81.10 ± 4.43	-0.996	0.331
	T-Ch	109.9 ± 5.52	109.7 ± 5.82	-0.699	0.493

*The difference was statistically significant(*P*<0.05)

Table 4
Results of the facial soft tissue symmetry in patients with UCLP

Region	Measurements	Fissure side(n = 18)	Non-fissure side(n = 18)	T	*P*
		Mean ± SD	Mean ± SD		
Upper part of face	Ex-En	23.01 ± 1.43	23.13 ± 1.60	-0.611	0.549
	En-N’	22.66 ± 1.64	22.66 ± 1.49	0.021	0.984
Nose	Sbal-Sni	10.72 ± 1.51	7.95 ± 1.81	6.226	**0.000***
	Sbal-C	11.50 ± 1.43	10.02 ± 1.62	5.399	**0.000***
	Sni-Ali	11.32 ± 1.74	10.85 ± 1.70	1.166	0.260
	En-Ac	41.37 ± 3.80	40.90 ± 3.68	1.196	0.248
	Ac-Prn	24.16 ± 3.24	27.51 ± 2.93	-7.162	**0.000***
	Sni-C	4.40 ± 0.94	4.46 ± 1.08	− .325	0.749
Lip	Ch-Ac	25.37 ± 1.94	26.20 ± 2.52	-2.318	**0.033***
	Cph-Sn	16.72 ± 2.34	14.02 ± 1.53	4.887	**0.000***
	Cph-Sbal	14.55 ± 3.67	16.72 ± 2.34	-4.161	**0.001***
	Sbal-Ch	24.24 ± 2.07	24.92 ± 2.19	-2.106	**0.049***
Face depth	T-N	114.5 ± 7.52	114.8 ± 6.94	0.698	0.495
	T-Sn	115.2 ± 7.43	117.9 ± 7.47	-5.351	**0.000***
	T-Me'	131.8 ± 9.56	132.1 ± 9.46	0.444	0.663
	T-Ex	81.16 ± 6.76	81.42 ± 5.91	0.462	0.650
	T-Ch	105.9 ± 6.70	106.5 ± 6.18	0.925	0.368

*The difference was statistically significant(*P*<0.05)

The measurements of UCLP patients demonstrated no significant difference in the measurement indices of the upper part of face between the two sides (P > 0.05). Nasal measurements showed that the width of the base of the nostril (Sbal-Sni) and the axial length of nostril (Sbal-C) on the fissure side were larger than those on the non-fissure side. The nasal alar projection length (Ac-Prn) on the fissure side was smaller than that on the non-fissure side. The difference between the two sides was statistically significant (P < 0.05). There were significant differences in all lip measurement indices between the two sides (P < 0.05). The midfacial depth(T-Sn) of the fissure side was smaller than that of the non-fissure side, which was statistically significant (P < 0.05). The results are consistent with UCLA patients.

The deviation analysis chart shows that the darker the color, the greater the deviation between the original image and the mirror image, correlating with more serious asymmetry of the region. Moreover, it provides a clear, composite full-face image that demonstrates both the distribution of facial asymmetry and the degree of asymmetry deformity. The power of this chart lies in the range of the analysis, from a full-face composite picture, to the capability of calculating the deviation value at any single point on the deviation analysis chart. (Fig. 3, Fig. 4) The representative points were selected and the deviation values were calculated according to the color distribution of the deviation analysis chart. The facial asymmetry of UCLA patients occurred principally in the ala, nostril and cheilion, with a deviation of 2-4mm, considered as mild asymmetry. Patients with UCLP showed severe asymmetry, covering the entire midface, with a deviation value of 4–6 mm. (Fig. 5, Fig. 6)

Discussion

Exact facial symmetry would mean that the face could be divided into identical left and right halves by a straight line through the midpoint of the nose, lips and chin, and the pupil lines on both sides would be perpendicular to this line and located at equal distances on both sides[14].Facial asymmetry usually refers to any shape and size imbalances of the left and right sides of the face. Kuijpers's study confirmed that the asymmetry of soft tissue in the in the upper and middle part of the face was good in patients with skeletal class I, while the lower part of the face showed asymmetry, mainly in the chin[15].

Studies have shown that the facial soft tissue structure of patients with cleft lip and palate is different from that of normal peers[16], and can encompass a variety of facial asymmetric features[17–18]. There are many factors that affect the severity of the deformity, including the type of fissure, race, sex, the type and timing of the operation. [19–21]

Although the study of facial symmetry has been widely carried out in normal people and patients with cranio-maxillofacial deformities, there are few reports on the long-term effects of growth and development on facial symmetry. For cleft lip and palate patients with severe facial deformities, the changes associated with increasing age, growth and development, and interventions on facial symmetry remain unclear. Facial asymmetry is expected in normal people, which complicates analysis of facial asymmetry caused by cleft lip and palate. Therefore, the intent of this study was to carry out a cross-sectional study of the symmetry on both sides of the patient's face, reducing the impact of other influencing factors.

The average age of cleft lip and palate patients in the present study was 11.2 years, which corresponded to the early stage of puberty. The patients had not yet undergone alveolar process cleft bone grafting and had no previous orthodontic treatment. These inclusion requirements helped to minimize the effect of other treatment interventions on facial soft tissue morphology with the exception of cleft lip and palate repair during infancy. It weakened the effect of growth and development and functional factors on facial morphology.

The whole midfacial region of patients with cleft lip and palate is considered a “problem area”[22]. As a result of both the defect and the operation, insufficient development in the midface can be observed[23]. In these patients, the continuity of upper lip muscle, upper dental arch and palate is interrupted, which leads to the destruction of stress support. In addition, due to the imbalance of tension and traction between the muscles on both sides of the upper lip, growth stimulation of the maxilla on the fissure side is weakened and growth is inhibited.

The congenital structural abnormalities and secondary tooth deformities in patients with cleft lip and palate lead to differences in bilateral function, and these functional disparities further aggravate the craniofacial abnormalities. Surgical trauma and other factors can also cause severe craniofacial asymmetry, potentially involving both hard and soft tissue, especially in patients with unilateral cleft lip and palate. There is an important proportional relationship between the morphology of facial soft tissue and underlying hard tissue. Abnormalities of hard tissue will lead to morphological abnormalities of the corresponding soft tissue, and the soft tissue can only cover up and obscure the morphological abnormalities of hard tissue to a limited extent. But outcomes of hard tissue repair cannot always be expected to apply to adjacent soft tissue. Studies have reported asymmetry of lip muscle tension even following successful cleft lip repair in patients with unilateral cleft lip and palate. In fact, this may be one of the underlying reasons for the asymmetry of maxillofacial development[24].

The upper part of the face in both UCLA and UCLP groups was less affected by fissures and had better symmetry. In prior studies of UCLP patients, the nose has generally been asymmetric; the tip of the nose having been deformed, straightened and deviated towards the unaffected side. Bagante reported that alar wing length was shorter and flatter on the cleft side of the nose for patients with UCLP[4], which is consistent with the alar projection length (Ac-Prn) in the two patient groups in this study.

A number of studies have reported that the increase in nasal width is the most striking finding regarding the nose in patients with BCLP, and the increased ratio of nose width to lip width negatively affected cosmetic appearance[18, 25]. The alar base shape was even more flat due to insufficient bone support in the affected areas[26]. Furthermore, nose width was increased and the columella was wider and shorter on the cleft side[27,16–17]. Bugaighis found that the UCLP group had a significantly shorter nasal bridge, broader anatomic and basal nasal widths, and a wider repaired nostril[28]. Zreaqat also concluded that the width of the alar base was mainly related to the fissure side[27]. In our study, nasal measurements showed that there were asymmetrical deformities in both horizontal and vertical directions, mainly in the nostrils and alae of the nose. The base width of the nostril (Sbal-Sni) was increased significantly on the fissure side in both UCLA and UCLP groups, mirroring the results of previous studies. This is a principal reason that affects the nasal symmetry of patients with cleft lip and palate. More attention should be paid to the correction of this in subsequent nasolabial repair in order to restore the beauty and symmetry of the nose.

There were statistically significant differences in lip measurements between UCLA and UCLP groups. The fissure side of these indices (Ch-Ac□Cph-Sbal□Sbal-Ch) was smaller than the non-fissure side. It has been postulated that this may be related to nasal collapse secondary to hypoplasia of the cleft jaw. The index of Cph-Sn suggested that the fissure side was larger than the non-fissure side, possibly related to asymmetry of the Christa philtri point on both sides. The Christa philtri point of the fissure side was lower than the non-fissure side, which was the cause of the morphological asymmetry of the upper lip and the philtrum. Previous studies have focused more on lip height with similar results. Bugaighis reported that the philtrum was wider, and a shorter upper lip length was found on the fissure side in the UCLP group[28].

In the present study, the depth of the midface of the fissure side was smaller than the non-fissure side in both groups. The growth and development of the middle part of the face on the fissure side was affected by the fissure, and was insufficient. The middle part of the face collapsed, the nose deviated to the fissure side, and the resultant appearance of the face was flat, in accordance with previous studies[28].

There is no consensus on soft tissue landmarks for three-dimensional facial image measurements in patients with cleft lip and palate. Different anthropometric points and indicators are used to evaluate the soft tissue of patients with cleft lip and palate[26−32]. The three-dimensional analysis and evaluation system of maxillofacial soft tissue in this study refers to the research of Alpagan and other scholars when selecting facial landmarks and measurement indices, and makes corresponding choices according to the facial soft tissue characteristics according to patient age. In the present study, the landmarks that were selected had strong characteristics that facilitated high repeatability, and measurement indicators that could reflect three-dimensional features to produce a comprehensive and systematic evaluation of maxillofacial soft tissue. To ensure the consistency and accuracy of soft tissue landmarks, the three-dimensional images were measured every two weeks, repeated three times, and the average of the three measurements was used as the final measurement.

Most studies on facial morphology of patients with cleft lip and palate are based on two-dimensional plane measurement, and the subjects are mostly adults. There are few studies on facial soft tissue morphology of preadolescent patients with cleft lip and palate. Previously used methods for the study of facial morphology included direct measurement, facial photography, X-rays, and Cone Beam CT. These measurement methods have limitations. Facial photos have low resolution and lack three-dimensional visualization. The soft tissue cannot be fully evaluated. Although the lateral cephalogram shows the whole craniofacial outline and is not hindered by the overlapping structure, the structure is limited to the midline plane and cannot be examined and evaluated in detail. CBCT can produce three-dimensional visualization and asymmetric evaluation, but it may require long exposures with the attendant radiation and necessitating considerable patient cooperation of patients. Repeated use for long-term follow-up or to record growth changes only compounds these risks and seems unreasonable. At present, three-dimensional technology can evaluate the therapeutic outcomes of cleft lip and palate more objectively, and three-dimensional photography is the optimal choice for soft tissue analysis[15, 33].

The reconstruction of deformities in patients with cleft lip and palate requires not only attention to soft tissue, but also the bone. But three-dimensional photography cannot image bone. Therefore, a combination of three-dimensional photography and CBCT can be instrumental in formulating the design of soft and hard tissue simulation surgery. The evaluation of soft tissue changes both before and following treatment seems more intuitive, and an even better plan to achieve successful outcomes would be facilitated with a combination of the two groups of data. In this study, we only used three-dimensional photography to measure and evaluate the soft tissue asymmetry of patients with cleft lip and palate, without use of CBCT to measure the bony tissue. The combination of these 2 modalities to fully characterize the soft and hard tissues will be the direction of our next research effort.

According to the deviation analysis chart in this study, patients with UCLA showed mild asymmetry, mainly in the ala, nostril and cheilion. Patients with UCLP showed severe asymmetry, covering the entire midface. The conclusion is consistent with the results of facial soft tissue morphology and symmetry analysis based on line distance measurement.

Once the data are captured, the deviation analysis chart has the advantages of simple operation and objective evaluation of the symmetry of facial soft tissue. It can qualitatively and quantitatively analyze the asymmetric distribution and degree of the face and provide a composite picture for orthodontists to achieve an understanding of the facial symmetry of these patients.

With the continuous progress of medical treatment, the orthodontic treatment of cleft lip and palate is also improving. Doctors and patients have higher aesthetic expectations for treatment. However, the treatment of patients with cleft lip and palate is often difficult to achieve a perfect result due to severe tissue defects and postoperative scar tissue. Many orthodontists are deterred from treating cleft lip and palate patients because of the difficulty of treatment, the complexity of the design of the treatment and the less-than-perfect therapeutic outcome. Therefore, accurate evaluation of facial soft tissue morphology in patients with cleft lip and palate becomes even more important. This will help orthodontists and plastic surgeons to obtain more comprehensive morphological information of maxillofacial soft tissue, so as to make a more accurate diagnosis and treatment design for these patients. It will also facilitate effective preoperative communication between doctors and patients' family members.

In this study, a three-dimensional photography system was used to obtain the maxillofacial soft tissue morphological data of cleft lip and palate patients to construct a three-dimensional digital model of maxillofacial soft tissue. We compared and evaluated the facial soft tissue morphology and asymmetric deformities of cleft lip and palate patients using this technology, improved the three-dimensional detection method of maxillofacial soft tissue morphology, and explored the morphological rules of nasolabial deformities after cleft lip and palate surgery. We hope to provide a reference standard for the measurement and analysis of facial soft tissue morphology in patients with cleft lip and palate.

Conclusion

The facial soft tissue asymmetry of patients of UCLA and UCLP was principally in the nasolabial region, and the range of asymmetry in patients with UCLP was wider and the degree of asymmetry was greater than in patients with UCLA.

Patients in both study groups continued to show facial soft tissue deformity in three-dimensional evaluation in prepuberty. It was principally manifested, but not limited to, the nasolabial area. Therefore, the repair of soft tissue in the nasolabial region of cleft lip and palate by childhood is very limited, and the facial malformation of patients in both groups would still require additional improvement with subsequent treatment.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the ethics review board of Tianjin Stomatological Hospital. We have obtained written informed consent from all study participants. All of the procedures were performed in accordance with the Declaration of Helsinki and relevant policies in China. Written informed consent was obtained from all subjects and/or their legal guardian(for minor participants).

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

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Author’s Contributions

Lijuan Zhou, Yang Cao and Meichao Wang contributed equally to this study. Lijuan Zhou, Yang Cao, and Meichao Wang conceived the study. Yang Cao and Ziyuan Guo developed search strategies. Lijuan Zhou and Ziyuan Guo wrote the first draft. Meichao Wang and Ximeng Zhang revised the draft. All authors approve the publication of this protocol.

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Figures

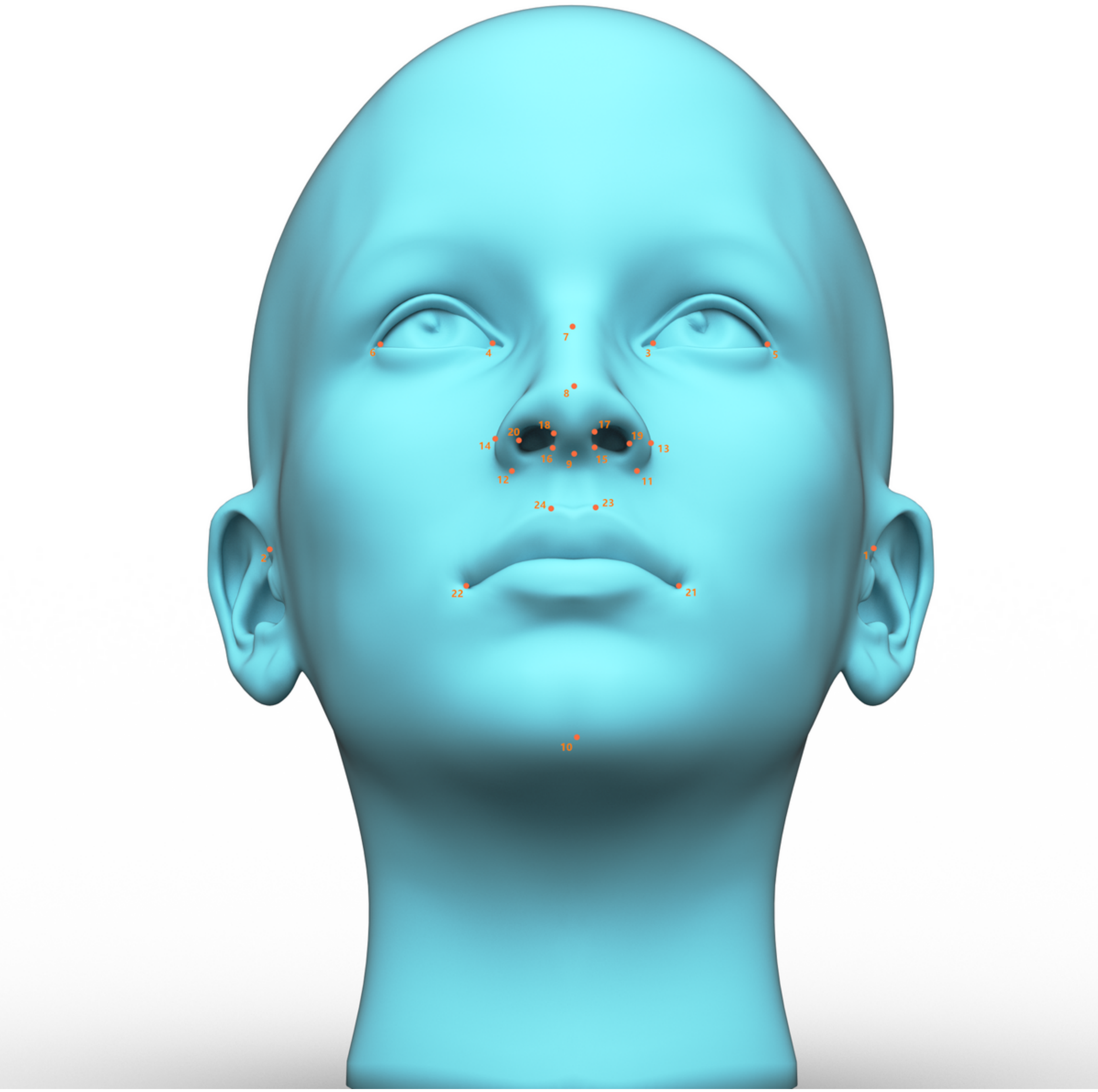

Figure 1

Facial soft tissue measurement landmarks

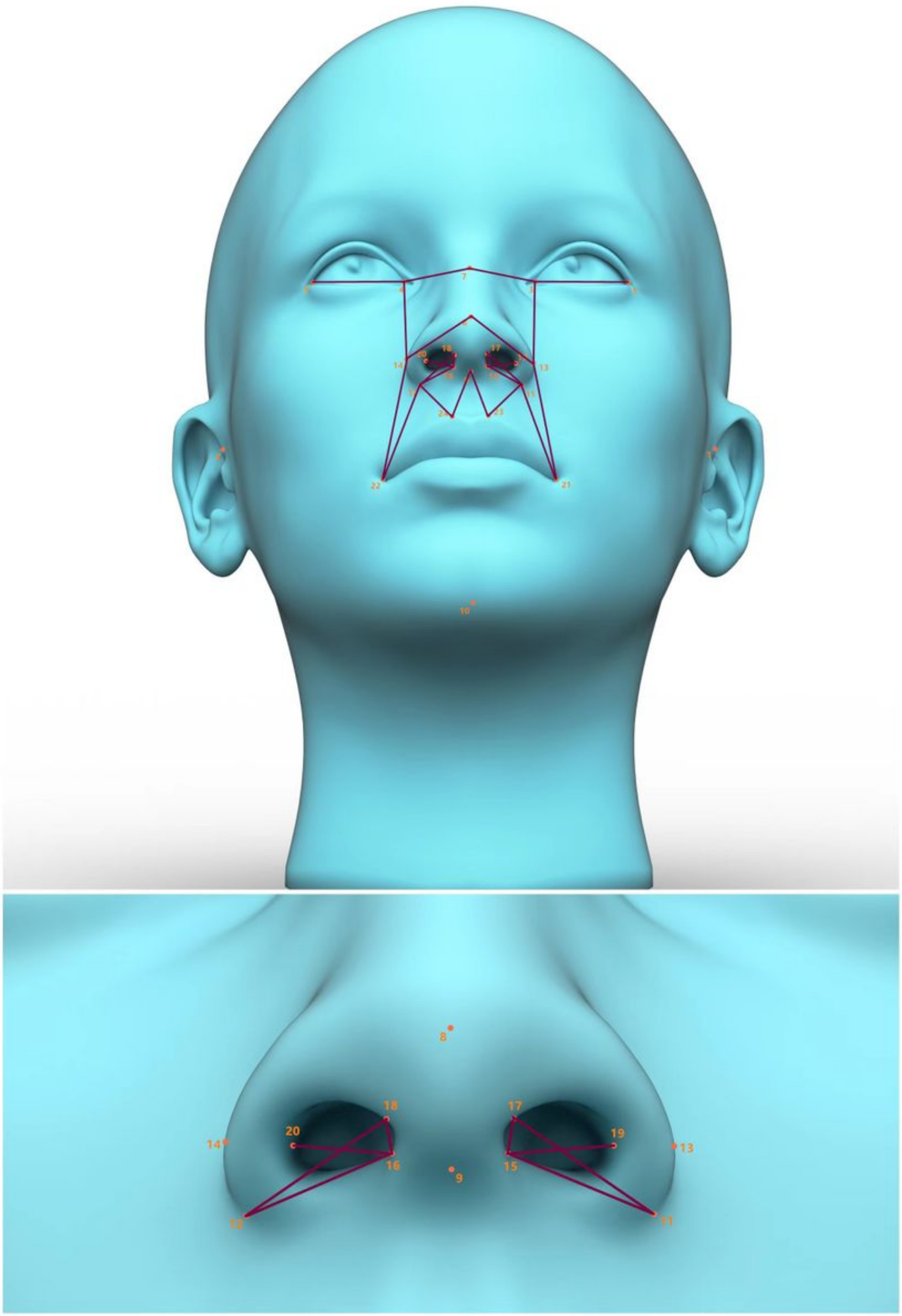

Figure 2

Measurement index of facial soft tissue symmetry

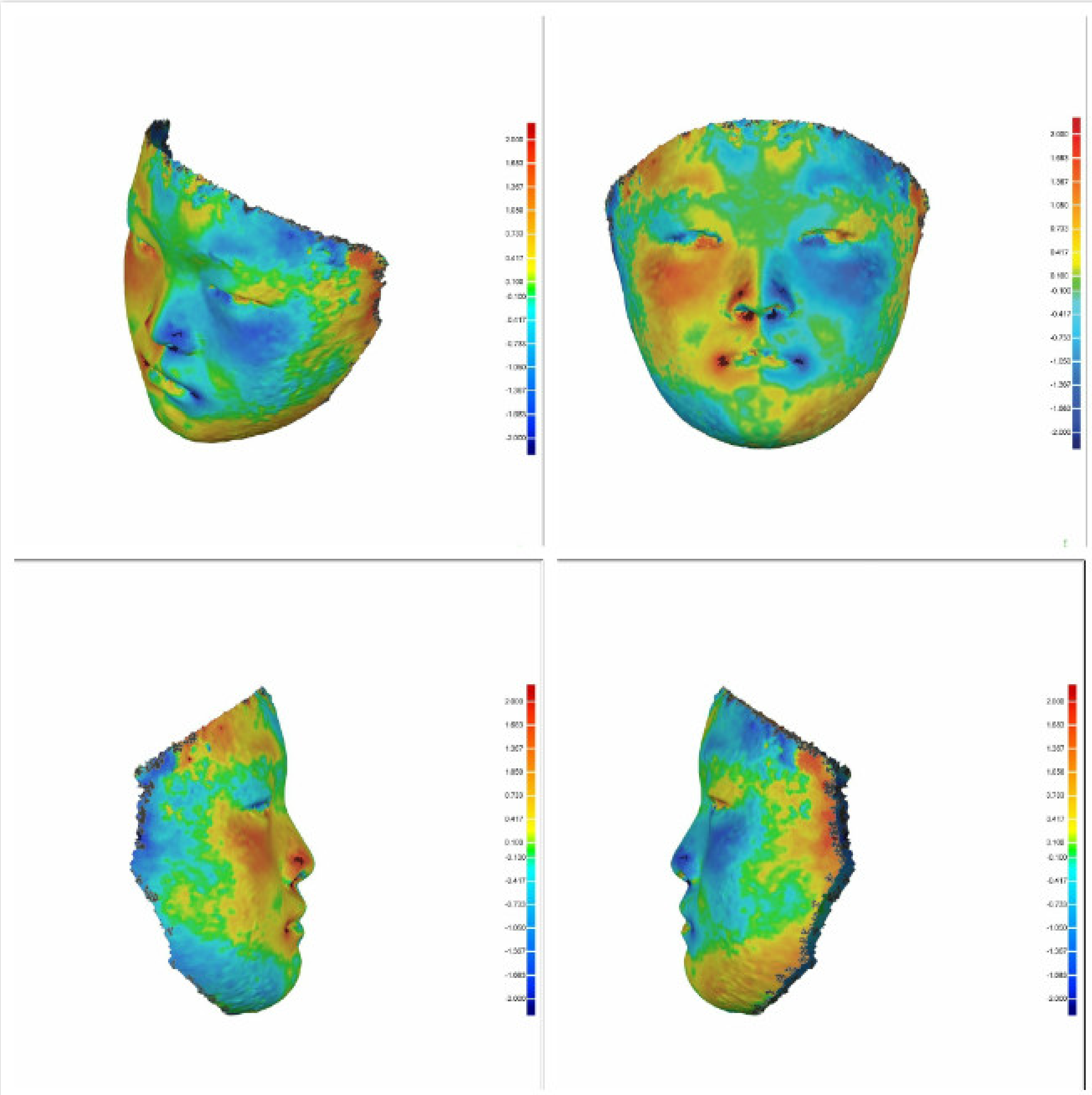

Figure 3

Deviation analysis chart of patient with unilateral cleft lip with alveolar cleft

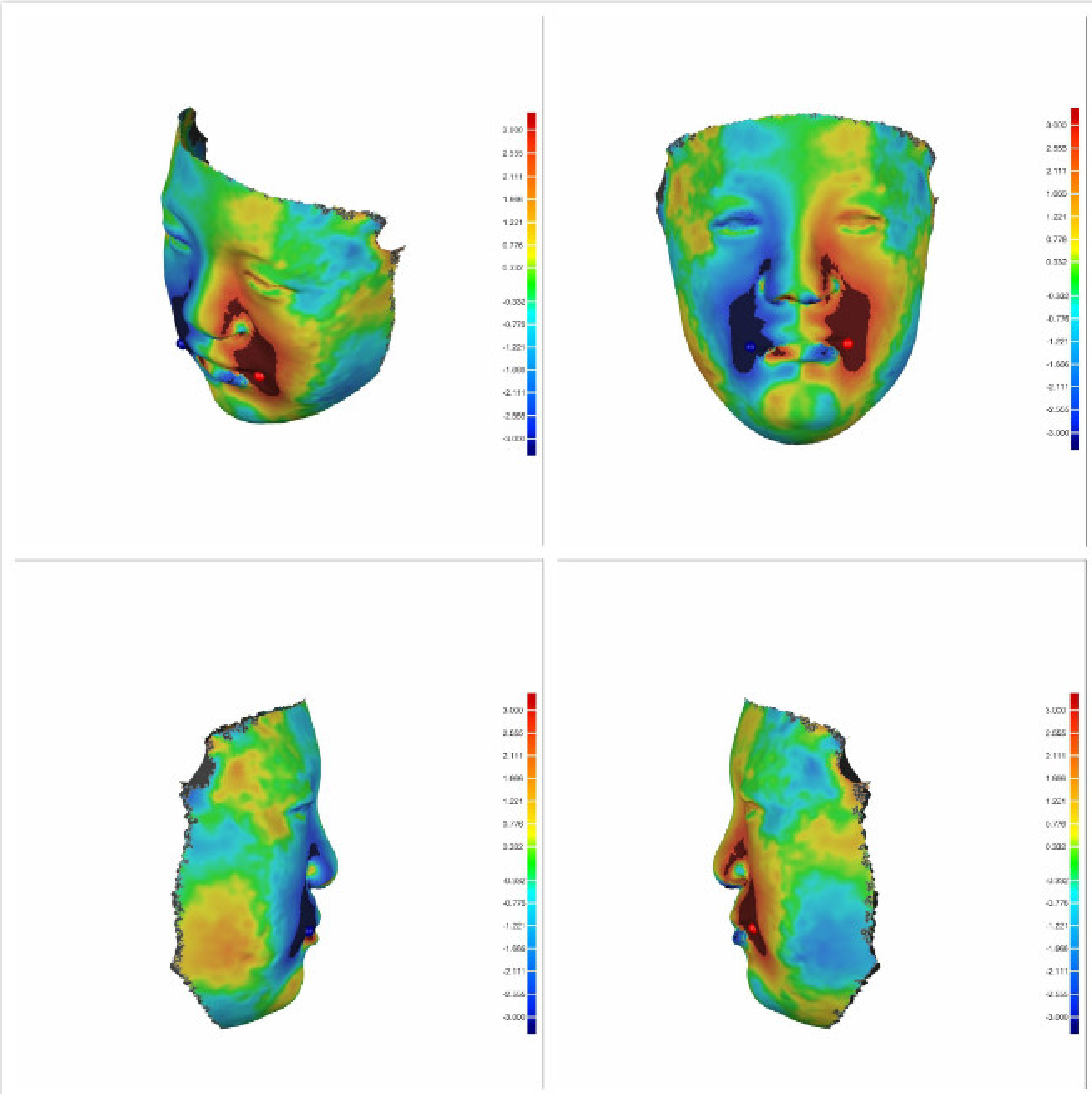

Figure 4

Deviation analysis chart of patient with unilateral complete cleft lip and palate

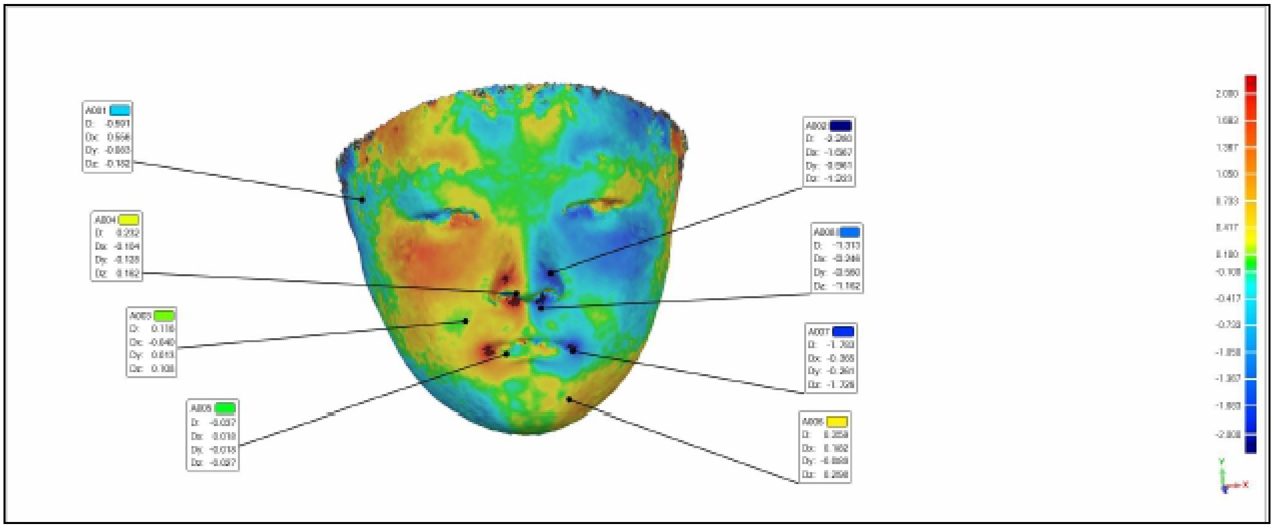

Figure 5

Distance difference of deviation analysis chart of patient with unilateral cleft lip with alveolar cleft

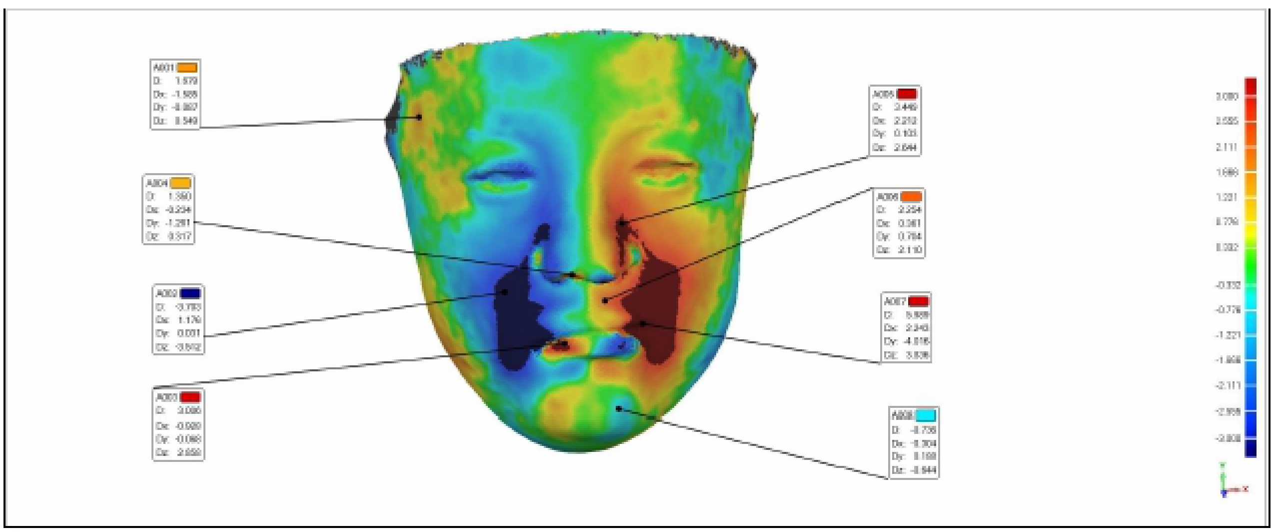

Figure 6

Distance difference of deviation analysis chart of patient with unilateral complete cleft lip and palate