With the development of three-dimensional imaging technology, three-dimensional facial stereography technology is becoming more and more popular in clinical medicine and laboratory research. The common three-dimensional facial stereography system is based on digital stereo photogrammetry technology, which is characterized by accurate reproduction of the three-dimensional contour of the face, vivid reflection of the color and texture of the skin, fast speed of data collection, wide coverage and safety without radiation. In orthognathic surgery, facial soft tissues, facial hard tissues and dentition are three key factors. In traditional photography, two-dimensional photographs often do not reflect the characteristics of patients’ three-dimensional structure. When applied to face simulation and prediction, they can only reflect the changes of facial profile, but ignore the overall and positive changes. The photographs provided by the three-dimensional facial stereography system can truly reflect the characteristics of facial soft tissues of the subjects, can be used for indirect facial measurement, and can also be applied to the establishment and analysis of three-dimensional models.
calibration. M4D system is a portable three-dimensional stereography system, which is small and portable, can be installed and used in a short time, can tolerate the slight movement of objects, and can be used for photography of any part of the body. Passive photography is to capture the reflection of light on the object's surface in the environment, which relies on triangulation technology on the actual surface of the object. The system relies on the details of the skin, hair, scars, freckles and so on. Therefore, it largely depends on the integrity of the pixels and requires higher camera pixels. In addition, the lighting conditions in the environment should be strictly controlled in order to minimize the impact of environmental spectral reflection on imaging. The commonly used passive three-dimensional stereography system is Di3D system, which uses high-resolution camera, does not need image projection or laser scanning, and can capture images quickly and easily. Mixed technology combines the above two technologies, and the most commonly used are 3DMD system. The 3DMD system is composed of six medical-level cameras, which can synchronize with the main body in 1.5 milliseconds. These cameras reconstruct the multi-angle images in the same three-dimensional coordinate model. The capturing time is short; and the 3DMD system can accommodate additional cameras without affecting the capturing time. However, the system requires users to calibrate them every time before use.

The accuracy of three-dimensional stereography system is mainly reflected in the repeatability and absolute accuracy. Some scholars [6] have found that the overall accuracy of 3DMD is less than 1mm with high reliability and repeatability when comparing 18 marker points measured by standard anthropometry and 3DMD system in 20 normal adults. A large number of scholars [7-9] found that the three-dimensional stereography system used in the market has high repeatability and accuracy when studying the accuracy of different imaging systems. Although there are gaps between different systems, these gaps are within the micron level, which is not very significant in the actual measurement research.

**APPLICATION OF THREE-DIMENSIONAL FACIAL STEREOGRAPHY IN ORTHOGNATHIC SURGERY**

Orthognathic surgery restores normal tooth-jaw position by cutting, moving and re-fixing the jaw. Before the implementation of the treatment plan, we simulate the tooth and jaw movement process and predict the changes of facial shape after operation, and get a visual effect map. This design method and prediction method is called VOT analysis method. Its purposes include: 1. to determine the target of preoperative orthodontic treatment; 2. to screen the surgical plan that can achieve the best functional and aesthetic effect; 3. to obtain the visual picture of the changes of facial profile after operation for consultation and communication with patients [10]. With the development of computer image and image processing technology, computer-aided design methods have become very popular. The emergence and development of three-dimensional imaging technology provides the possibility of measurement, design and simulation of three-dimensional models.

**The Role of Three-dimensional Facial Stereography in Facial Measurement**

Traditional anthropometry is carried out in the clinical environment, which measures the distance or radian between the marker points of the object with calipers. It needs to measure the object independently, and requires several minutes of direct physical contact. It is difficult to collect data of infants or children with some developmental deficiencies and takes longer time. When three-dimensional stereography system is used for indirect measurement, it has great advantages [11]: firstly, it is finished fast, and the object can move freely after it is done; secondly, the photography system is non-invasive, safe without radiation; thirdly, after it is done, the image can be quickly viewed to determine the photographic details, if defects or deformations are found in the image, it can be recaptured in time; fourthly, the image data can be used repeatedly after archiving for research and measurement; finally, the data can be used in computer software to measure the distance and radian between marker points. The same data can be measured and analyzed by multiple people at the same time. Three-dimensional facial stereography is mainly used to measure and analyze the relationship between marker points of facial soft tissues, but not that for hard tissues. As an indirect measurement method, it cannot determine the location of marker points by touching the object directly, but can only be judged by facial contour. Computer software has the function of local enlargement. Individual differences may exist when marking points are placed. Therefore, physicians need to check the location repeatedly when marking. Whether it is traditional direct facial measurement or three-dimensional facial photogrammetry, most of them pay attention to the distance between the marker points and the linear angle relationship of the side correlation, rather than the radian...
of the facial contour, thus are lacking in the measurement
indicators of the characteristics of three-dimensional facial
photogrammetry.

Three-dimensional facial stereography also has great
advantages in symmetry comparison. In anthropological
research, facial symmetry is very important in human facial
attraction. Local symmetry has different importance in
different regions of the face, and symmetry near the midline
has a greater impact. In the comparison of symmetry, two-
dimensional photographs sometimes have little difference
in height and width because of the lack of coordinates of
one dimension, but there may be great difference in depth.
In addition, a single two-dimensional photograph has
less available measurement indicator points than three-
dimensional model in symmetry comparison, and gives
less comprehensive information. Philipp et al. [13], when
comparing the 3 methods of facial symmetry analysis via
two-dimensional and three-dimensional photographs,
pointed out that two-dimensional photographs have some
deficiencies in the accuracy while three-dimensional
photographs are more difficult to be measured due to larger
number of available marker points, and suggested that the
three-dimensional photos should be analyzed by referring
to the symmetry index in the two-dimensional photos, so as
to get the accurate results quickly. The results of symmetry
analysis can provide certain guidance for the treatment plan
and operation plan. Complete and accurate results can
provide better treatment.

Ogawa et al. [13] used three-dimensional facial stereography
system to obtain three-dimensional facial images of 1126
Japanese (865 males and 261 females aged 19-60) as
samples. Under the standard anthropometric analysis,
the features of eyebrow, orbit, nose and lip contours were
recorded, and the differences between different ages and
genders were compared to establish the database of three-
dimensional facial photographs, which can not only be
used to analyze the differences in facial contour and soft
tissues characteristics of a group, but also to analyze the
development trend of the face with age by comparing its
changes horizontally. Kim [13], through the analysis of the
three-dimensional facial models of 43 beauty contestants
and 48 ordinary women, found the difference between the
two groups: the middle of the face of beauty contestants
is more three-dimensional, the nose is higher and the
distance between the two sides of the nose is shorter; there
is no significant difference between the vertical ratio of the
lip and the lower part, but the nasolabial angle of beauty
contestants is slightly larger than that of ordinary women.
There are also some differences in facial features among
different races. Wirthlin [14] compared three-dimensional
facial models of 100 white Houstonians with 71 Chinese,
and found that Houstonians have more protrusions in
the middle of the face, including the eyebrow, nose, lips
and chin while Chinese have wider zygomatic arch, and
Chinese women have fuller cheeks than men. These
differences have certain reference value in orthognathic
simulation, which is conducive to the formulation of more
reasonable treatment programs.

The Role of Three-dimensional Facial
Stereography in Preoperative Simulation

Cone-beam CT (CBCT) can provide medical image
storage and transmission data, which will not lose
the original information of the images, and realize
the consistence of the corresponding points of two-
dimensional photos with the three-dimensional spatial
position and anatomical structure by marching cubes
algorithm in computer graphics, to reconstruct the three-
dimensional visualization model [4, 15-19]. With the soft
and hard tissues data provided by CBCT, a three-dimensional
model is created, which is used by many scholars to
simulate the hard tissues morphology after the operation
by cutting and moving the jaw. This technology can also
be combined with three-dimensional printing technology to
print biteplate to be used during the operation. However,
the accuracy of facial soft tissues data provided by
CBCT is still inadequate. It cannot display the color and
texture of facial tissues. Fitting the images provided by
three-dimensional facial stereography with CBCT can
show the overall face and contour after operation. This
dimensional model can not only show the profile
relationship, but also show the relative relationship
between the positive side and the whole face. It can be
used to observe the symmetry of the face. It is more
intuitive than the two-dimensional simulation, and has
more advantages in the determination of treatment options
and doctor-patient communication.

A large number of scholars combined three-dimensional
facial photographs and CBCT to simulate orthognathic
surgery, and found that the accuracy of three-dimensional
simulation is higher than that of two-dimensional simulation
in soft tissues prediction [20-27]. The errors in three-
dimensional simulation are the errors in data acquisition or
processing on one hand, and the errors in simulation itself
on the other hand. The error between the acquisition of
three-dimensional facial stereography and the acquisition
of CBCT is relatively small, but when acquiring three-
dimensional facial images, the instantaneous facial images
are captured. The three-dimensional image acquisition and CBCT image acquisition are not carried out at the same time; swallowing, mouth-sweeping and other movements will affect facial morphology through muscles. When the subjects are in the position of rest and occlusion, the lower third of the face may be different in height. Therefore, it is suggested that a unified image acquisition standard be established to reduce the errors caused by data fitting. In software simulation, the changes of hard tissues lead to the changes of facial muscle tension, and the changes caused by different amount of movement are different, and the changes are not completely in accordance with the linear relationship; on the other hand, there are differences in the thickness of soft tissues between different individuals, leading to differences in individual simulation. In many cases, individual differences in three-dimensional simulation are adjusted individually based on the doctor’s clinical experience. There is still a lack of a database to simulate the relative relationship between soft and hard tissues in the three-dimensional simulation, which can guide the adjustment of patients with different soft tissues thickness and the amount of hard tissues movement.

### 2 Application of Three-dimensional Facial Stereography in the Comparison of Treatment Effects

In researching the difference before and after treatment of orthognathic patients, we can mark reference points on the model, draw reference lines, compare the difference between marker points and reference lines, or use computer software combined with algorithm to overlap the three-dimensional facial models before and after treatment, observe the difference of overlapping effect in the software and analyze it. Computer software can also quantify the differences in facial volume change. Hajeer \(^{[28]}\) compared the three-dimensional models of five patients with orthognathic surgery before and after surgery, and found that orthognathic surgery improved the symmetry of the soft tissues morphology of lower 1/3 part of the face. Three-dimensional facial photographs can record the features of facial contour, color and skin texture of the subjects. The photographing process is simple, safe and without radiation. It can be used to record facial features of orthognathic patients during subsequent re-check and follow-up. Kau et al. \(^{[29]}\) also used it to compare the rate of swelling subsidence after orthognathic surgery, and found that within one month the individual swelling subsided by about 60%. The swelling produced by bimaxillary surgery was larger, but the rate of subsidence was faster than that of unimaxillary surgery. Combining with computer software algorithm, three-dimensional facial photographs can be used to quantify the volume changes of the face, and can be used to observe the results of treatment and analyze the prognosis in local facial filling treatment.

### CONCLUSIONS & PROSPECTS

The application of three-dimensional facial stereography in facial soft tissues acquisition has the characteristics of fast speed, high accuracy, high repeatability and non-invasiveness. It can be used in the analysis and measurement of facial soft tissues. It can not only quantitatively analyze the relationship between facial markers, but also quantitatively analyze the symmetry and volume changes of the face. When it is used to build a three-dimensional facial model, it can simulate the whole facial soft tissues morphology after orthognathic surgery, and has a higher accuracy. It has a greater advantage in the determination of orthognathic treatment plans and doctor-patient communication. The system can record the facial soft tissues characteristics of the object completely, and has great advantages in the follow-up and research after operation.

However, when three-dimensional facial photos are used in three-dimensional simulation, the lack of a three-dimensional database leads to errors in simulation. Although many scholars are gradually expanding the amount of data in order to establish a perfect database, there is no unified conclusion on the correlation between preoperative simulation and postoperative three-dimensional facial photographs in orthognathic surgery simulation, and doctors still need to explore and summarize. There is also a lack of standardization in three-dimensional facial photo acquisition, which will affect the accuracy of data acquisition and the accuracy of three-dimensional simulation results.

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### REFERENCES
