A REVIEW OF STUDIES ON THE ORAL REPAIR SYSTEM

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ABSTRACT

With the development of economy, people's focus on oral medicine has changed from solving diseases to improving people's quality of life. For example, patients are no longer satisfied with the restoration of basic chewing functions, but pay more attention to the beauty and appearance of their restored teeth. However, aesthetics is highly subjective, and the traditional method of making restorations is inefficient and cumbersome, which can no longer meet the needs. The application of digital technology provides great possibility and convenience for the realization of patients' personalized requirements. In the field of stomatology, people have higher and higher requirements for digital technology. In the field of dental aesthetic restoration, the two-dimensional pictures of beautiful teeth made by DSD (Digital Smile Designer, Digital Smile design) can preview the effect of dental beautification to patients, which is an important medium for doctor-patient communication. Among them, the data display and simulation effect with higher requirements is one of the key studies at present. This paper will introduce in detail the key techniques and applications of the oral prosthesis system.

KEYWORDS: Digital technology, Oral repair system, Oral medicine, DSD.

1. INTRODUCTION:

With the development of economy, people's focus on oral medicine has changed from solving diseases to improving people's quality of life. For example, patients are no longer satisfied with the restoration of basic chewing functions, but pay more attention to the beauty and appearance of their restored teeth. There are many defects that affect the appearance of the anterior teeth, including tooth defects, bad color, uneven tooth alignment, excessive tooth gap, tooth loss, and poor gum aesthetics [1].However, aesthetics is highly subjective, and the traditional low-efficient method of making restorations can no longer meet the needs. The application of digital technology provides great possibility and convenience for the realization of this personalized aesthetic demand. In the field of stomatology, people have higher and higher requirements for digital technology [2].Among them, the data display and simulation effect with higher requirements is one of the key studies at present.

In aesthetic dental repair, tooth color is of vital importance [3].Existing studies have found that tooth color is one of the important factors influencing patients' satisfaction with the results of dental aesthetic repair [4].Many patients expressed interest in having realistic textures on digital prosthetics [5,6].In the aesthetic restoration, the restoration of the upper jaw dentition is the main. One way to obtain the realistic maxillary dentition model is to obtain it directly through the expensive intraoral scanner. Obviously, this method is too expensive and will increase the operating cost of oral medical institutions. Moreover, the color textured dentition model obtained by most manufacturers' intraoral scanners can only be used in their own software system, which is too closed. The other method is through computer aided technology and some effective methods of computer graphics, the use of low-cost equipment can easily obtain the realistic color dentition model.

In the field of dental aesthetic restoration, the two-dimensional pictures of beautiful teeth made by DSD (Digital Smile Designer, Digital Smile design) can preview the effect of dental beautification to patients, which is an important medium for doctor-patient communication.

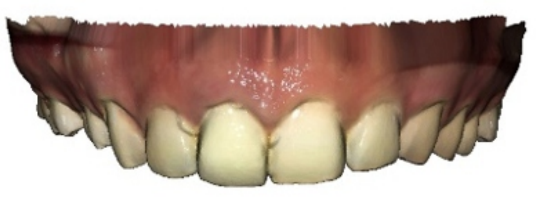
However, in the practical application of the two-dimensional beautiful tooth system, the guidance of the two-dimensional beautiful tooth information on the oral cavity repair operation itself is still limited, so the market is in urgent need of a three-dimensional dental model repair method guided by the two-dimensional beautiful tooth information. In this way, under the condition of satisfying the doctor-patient communication, manual operation steps can be simplified, and 3D printing technology can be used to print the 3D dental model after beautification and restoration, which can be directly applied to clinical surgery. It can greatly improve the efficiency of medical plan implementation and provide possibility for personalized aesthetic repair needs of patients.

2. REVIEW OF RELATED STUDIES:

2.1 Construction of realistic dental model:

In computer graphics, the method of overlaying multiple photos on 3D models to obtain realistic models has always attracted people's attention. The general method mainly includes 2d-3d registration, projection texture mapping and texture fusion [7-9].Estimating the relative pose between a 3D object and its 2D projection is a basic problem for 2d-3d registration in computer vision and medical imaging.It is not easy to establish the corresponding relationship between 2D and 3D points, although feature extraction and matching between 3D point clouds or 2D images is quite mature technology.However, due to the loss of 3D geometric attributes in 2D projection, it is very difficult to match 2D and 3D features, easily causing distortion, occlusion and other problems [10].For example, features on a 3D model often explore the 3D geometry of an object, which is lost in a 2D projection, while features on a 2D image often make use of image textures that are either unavailable in the 3D model or severely distorted in the 2D projection.In the process of constructing the realistic 3D model, the relative pose between the 3D object and its 2D projection is found, that is, the internal and external parameters of the imaging camera are calculated.In this way, the projection transformation matrix is calculated based on the internal and external parameters of the camera to obtain the 2D texture coordinates, and the mapping relationship between the 2D texture image and the 3D model is established to transfer the color information from the image to the 3D model, as shown in figure 1.


a. left view


b. front view


c. right view

Figure 1: Construction of realistic dental model

In 2017, Ruggero Pintus et al. [6] summarized 5 methods of 2d-3d registration: artificial method [11-12], feature method [13], color method [14], mutual information method [15] and multi-view method [16-19].At present, most of the methods based on the first four are for registration of an image, while only the method based on multiple views considers multi-texture registration and fusion.

In 2018, Walter YH Lam et al. [6] proposed an automatic feature extraction method for image to dentition geometric registration. Firstly, the features of the mesh model were extracted based on the mean curvature of the 3D dental mold, then the teeth were separated according to the color of the 2D image and the turning points on the boundary were searched, and finally the image to geometry was automatically registered and mapped based on the feature points found. To some extent, this method can realize the automatic registration of image to geometry, but only one in-mouth image can be registered to 3D dental model based on this framework, which results in that only some geometric surfaces of the lips, premolars and buccal surfaces of the teeth can be mapped to color images. Second, an important prerequisite for the automation of the method is the use of standardized methods to take photos. So that the teeth of the central incisor and the occlusal line are approximately centered and aligned horizontally with the frame of the image. This is equivalent to the continuation of manual operation to the shooting process of the inside of the mouth, a higher requirement on the shooting Angle of the photo.

In 2018,LiuYuShu et al. [23] using foreign 3 shape Dental System and 3 shape Ortho digital zhengji rehabilitation combined treatment design System analysis in the application of anterior teeth aesthetic reconstruction effect, by comparison with cases prove that the digital zhengji rehabilitation combined treatment design is feasible, can provide the final effect prediction for patients before treatment, provided the convenient conditions for the doctor-patient communication, help on the basis of patients satisfaction to achieve more ideal aesthetic effect. In 2018, Hsung et al. [5] used image-to-geometry registration to map the intraoral photograph to the virtual dental mold by marking corresponding feature points on 2D and 3D images. This method can be used to project the three - dimensional tooth mold with multiple internal images. However, this method needs to manually adjust the camera view during each projection, and manually mark a large number of feature points in the 2d-3d process in order to improve the registration accuracy. The whole process is complicated and complicated, which has high requirements on the operator's technology. The accuracy of the marker directly affects the final registration accuracy.

2.2 Dental shape restoration:

In terms of oral prosthesis, in 2011, Zheng et al. [20] proposed a new 3d reconstruction method for dental prosthesis. The missing Mosaic or coronal occlusal surfaces are reconstructed using 3D deformation techniques. The method involves three necessary steps: extraction of cavity contour, identification of feature points and deformation of tooth surface. Since the missing occlusal surface is usually determined by the contour of the remaining tooth cavity, the contour of the cavity is first tracked by the 3D optimal path search algorithm. The Snake model algorithm is then used to identify many of the corresponding feature points on the standard tooth and the remaining tooth. The method USES a mapping function called the radial basis function (RBF) to define the spatial relationship of all the points in the two teeth and inserts the intermediate feature position to make the surface of the standard tooth become aligned and to determine the missing surface. This provides a direct and simple method for automatic reconstruction of occlusal surfaces. The corresponding features are fully considered in the deformation algorithm, so the morphological features of teeth are well preserved.

In 2013, Nina et al. [21] proposed an effective hole filling algorithm to reconstruct the missing part of teeth and gums. The method is divided into four steps: boundary construction and projection, hole triangulation in 2D, vertex to 3D back-projection, and mesh rectification. By combining the constrained Delaunay triangulation in 2D with the vertex back projection using mean coordinates, the high robustness and high quality initial repair mesh of hole triangulation are realized.

In 2016, Ning Dai et al. [22] proposed a digital modeling method for full crown preparation. First, the edge line of tooth preparation was designed using semi-automatic interactive process. Second, the insertion direction is calculated automatically. On this basis, the characteristic parameters and constraint conditions of the model are defined. Then, the shoulder and axial surfaces of the tooth preparation were modeled by parametric modeling. Finally, the implicit surface radial basis function is used to construct the occlusal surface of the prefabricated teeth. The method still has shortcomings. For example, the design of prosthesis preparation usually requires the removal of all bottom cuts on the axial surface to match the convergence Angle, opening the prosthesis to repair space, and having a shape that promotes retention and resistance. Because of the limited operating space, dentists must operate in a small, semi-closed mouth because of soft tissue obstruction in the muscles of the tongue, lips and cheeks. Surgery is very difficult, dentists need to manually perform a lot of repetitive small operations, and human visual biases can make manual positioning difficult to control.

In 2005, Mehl et al. [24] made three-dimensional measurements of 174 decayed maxillary first molars in young patients aged 6-9 years. On this basis, the average tooth shape of the molars was calculated, the common features of the surface of the molars were obtained quantitatively, and an average form of the maxillary molars was constructed. Finally, the occlusal surface of the defect tooth was determined according to the difference between the defect tooth and the average tooth. The implementation of this method requires the establishment of dental database, which is a large workload.

In 2010, Yang feng [25] proposed a method to realize the invisible tooth correction technology, which extended the tooth movement mode to the method combining interactive movement and traction movement of dental arch line, and introduced collision detection technology to monitor the possible collision between teeth during tooth movement and tooth row. In 2011, Zheng[26] proposed a new three-dimensional deformation method for the reconstruction of the occlusal surface. The aim is to reconstruct the reasonable occlusal surface of the inlay/crown to maintain the morphological characteristics of the general teeth and to reduce the artificial contribution required in tooth shaping. The method involves three necessary steps: tooth contour extraction, feature point recognition and tooth surface deformation. This method is based on the curved feature of the standard tooth mold to repair the molar tooth mold without considering the occlusal feature of the lower jaw.

In 2011, Yan Guodong et al. [27] used the characteristic curve to drive the partial deformation of the tooth prosthesis surface to design the prosthesis surface morphology, and created a digital model of the prosthesis that was in line with the function of the patient's oral system. Firstly, the control points are selected interactively with mouse to construct the characteristic curve on the restoration surface, and the characteristic curve is projected onto the surface to generate the projection curve. Then, the projection curve is used to calculate the deformation region affected by the characteristic curve according to the defined deformation radius, and the mapping relationship between the points in the deformation region and the characteristic curve is established by KD tree structure. Finally, according to the constraint relationship between the adjacent tooth and the maxillary tooth, the control point can be changed to edit the characteristic curve, that is, the characteristic curve can drive the local deformation of the restoration surface. The practicability of the algorithm is verified by the local deformation of the anterior tooth tip and the restoration of the anterior tooth under the constraint condition of the adjacent tooth.

In 2012, Du Zhongyi [28] will be introduced to the digital geometry processing, such as invisible orthodontic teeth, to build the high accuracy of the teeth and gums model as the goal, to design a set of editing system for digital dental model, the system to provide the mesh repair, grid and grid optimization, the grid deformation, smoothing operation can provide complete data support for the teeth contact correction.

In 2014, fan ran et al. [29] proposed a reconstruction algorithm for restoration surfaces combining template feature line matching and moving least square deformation. This algorithm USES the intelligent scissors algorithm to semi-automatically specify the structural characteristic line on the tooth preparation, and USES the surface fitting technology to project the structural characteristic line to the template tooth model to establish the curve constraint. Then the approximate rigid moving least square deformation algorithm was used to match the template tooth model to the tooth preparation. Finally, the moving least square deformation algorithm is parallelized to realize the interactive design of the shape of the restoration body with the characteristic line as the control handle.

In 2016, Jiang et al. [30] proposed a robust tooth surface reconstruction algorithm suitable for all-ceramic crown design. The algorithm consists of three necessary steps: initial positioning and segmentation of the standard teeth; Using Morse theory to extract significant feature points; And use iterative Laplacian surface editing and mesh splicing for standard tooth deformation. The algorithm can well preserve the morphological features of the tooth surface. It is robust and suitable for almost all types of teeth, including incisors, canines, premolars and molars.

3. CONCLUSIONS AND SUGGESTIONS:

Although a large number of researchers continue to study the oral repair system, there are still a number of problems to be solved. For example, in the case of tooth color, there may be different colors in different mouth pictures. Many method values address the alignment of tooth textures with 3d models and the fusion of texture seams. It does not solve the problem that the brightness, contrast and saturation of tooth texture are affected by different lighting and shooting Angle in the actual shooting process of SLR cameras. These factors will directly affect the realism of the tooth model after texture mapping, which will greatly reduce the simulation effect. So, hope I can continue to research, and put forward relevant method, can solve the SLR camera automatically in the process of actual shooting, because the light and shooting Angle different, brightness, contrast, saturation of teeth texture, without having to manually adjust the brightness of the image, contrast, saturation, etc., to further improve the effect of 3D dental simulation.

In terms of aesthetic restoration, there is also a great deal of research to be carried out. For example, some methods do not take into account the occlusal relationship between the upper and lower jaw, or have a limited level of automation. In the process of three-dimensional dental model deformation, collision and penetration may occur between the triangular mesh models of the upper and lower jaw. If these potential problems are not solved, the prosthesis made according to the method in this paper will seriously affect the occlusion of the upper and lower jaw and the normal chewing function of the teeth. In order to study the virtual occlusal relationship of three-dimensional dental models, it is very important to obtain the initial relative position of the upper and lower jaw, which is the basis of the study of virtual occlusal.

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