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Screw-retained full arch restorations – methodology of computer aided design and manufacturing

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ABSTRACT

Purpose: The aim of the paper is to present the designing and manufacturing process of the screw-retained superstructure of the dental arch in the maxilla based on six implants using CAD/CAM technology.

Design/methodology/approach: The methodology is presented on the example of the implantoprosthetic treatment in a 55-year-old female patient with a significant deficit of the alveolar bone. 6 implants were placed to achieve a good anchorage for the ceramic suprastructure. The prosthetic reconstruction was milled out of a zirconium dioxide block and covered with veneering ceramics to obtain good aesthetics of the restoration. Special copings were designed and manufactured to achieve stabile connection between the implants and the suprastructure.

Findings: To properly plan the prosthetic work rebuilding the alveolar ridge on dental implants it is necessary to plan the final prosthetic work before implant placement planning the number of implants and their location in the bones and the possibility of using a fixed or a mobile suprastructure.

Practical implications: Design of the suprastructure has to take into account the following factors: 1. The number of implants, copings and openings for the abutment screws, 2. Arrangement of teeth in the prosthesis, 3. The shape of the alveolar ridge, 4. The shape of the space for the porcelain and for the individual crowns, which will be pasted on the suprastructure.

Originality/value: For technological reasons it is not possible to make an extensive suprastructure in a single piece. It is necessary to execute the foundation of the reconstruction of the alveolar ridge and the teeth in one piece and separately the individual crowns. It is possible, however, to design and manufacture the complex screw-retained prosthetic suprastructures by means of CAD/CAM technology.

Keywords: Zirconia dioxide; Screw-retained suprastructure; Implant dentistry; CAD/CAM; Implant coping

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BIOMEDICAL AND DENTAL MATERIALS AND ENGINEERING

1. Introduction

Implantoprosthetic treatment of patients involves the use of dental implants as a support for the prosthetic superstructure. Dental implants provide stability and retention for the superstructure. In some cases dental implants also carry the force of chewing triggered by the muscles directly to the alveolar bone [1-4].

Implantoprosthetic solutions in which chewing forces are transmitted through the dental implants to the alveolar bone are perceived by patients as the most comfortable. This is because the oral mucosa is not loaded with occlusal forces. The mucosa of the mouth is not designed to withstand the chewing action [5,6].

Implantoprosthetic solutions using implants to carry the forces of occlusion onto the alveolar bone reproduce also the functions of the stomatognathic system in the most physiological way. Dental implants play the role of artificial roots of missing teeth. They are then the parts of the whole reconstruction transmitting the occlusal forces directly to the alveolar bone [7,8].

In the simplest case the entire implantoprosthetic complex restoring the lack of a single tooth consists of three parts: a dental implant placed in the alveolar bone, an abutment screwed into the implant and a prosthetic crown attached to the abutment. The prosthetic crown in this case is the visible portion in the mouth and mimics the natural tooth. This portion of the whole system is responsible for accepting the chewing forces in contact with the opposing teeth [9,10].

There are two basic ways to connect the crown to the abutment. In the first method the crown is cemented to the abutment. In the second case, the crown is screwed onto the abutment with a special prosthetic screw [4,9].

Each of these solutions has its advantages and disadvantages. The main advantage of the cemented solutions is their simple technical manufacturing because the gap for the cement allows the forgiveness of some technical inaccuracies. In addition, the cemented crowns are more cosmetic, as there is no need for an access opening to the screw. The main disadvantage is the use of cement for mounting the crown to the abutment. During cementation the cement can be pushed below the gum line, which in many cases may lead to inflammation in the vicinity of the implant, which is called *cementitis* [11]. In addition, in some circumstances the crown may become loose and fall off the abutment causing aesthetic and functional problems. This forces the patient to seek help from a dentist who will cement the crown back to the abutment [12].

The use of screw-retained crowns is far more technically demanding. These solutions force the dental technician to plan precisely the prostheses, so that the walls of the crown can host the access openings to the abutment screws. Then, the access hole must be masked with a suitable material in the patient's mouth to ensure the adequate aesthetic of the whole reconstruction. The big advantage of the screw-retained suprastructures is virtually no possibility of accidental loosen of the prosthesis during normal use. During the installation of the crown there is no risk of pushing the cement into the area of the implant. In addition, there is a possibility of professional dismantling of the restoration for hygienic purposes [8,9,13].

It should be noted, however, that screw-retained prosthetic solutions are rarely selected by clinicians, mainly due to technical difficulties during the laboratory execution of these elements. In some cases, however, the screw-retained prostheses must be performed. The primary indication for screw-retained crowns is a small space between the top of the alveolar ridge at one side and the opposing teeth. Short abutments with relatively small contact area do not provide sufficient retention for cemented crowns. In addition, these solutions are used in extensive prosthetic works, particularly at the areas of deficits of alveolar bone, with no possibility of placing the implants in ideal positions corresponding to the position of artificial teeth. Then there is the possibility of introducing implants at the sites most favorable from the point of view of the bone condition. Then the prosthetic work is deigned to the requirements of the occlusal and aesthetic demands. Such a prosthetic superstructure is then attached with abutment screws to the previously entered implants [8-10].

The aim of the paper is to present the designing and manufacturing process of the screw-retained superstructure of the dental arch in the maxilla based on six implants using CAD/CAM technology.

2. Clinical case presentation and methodology

2.1. Clinical case presentation

Implantoprosthetic treatment was carried out in a 55-year-old female patient with a significant deficit of the alveolar bone (Fig. 1). The surgery used bone graft from her own tibia in order to lift the maxillary sinus on both sides. After 6 months of healing 6 implants were placed in the posterior maxilla with the use of a surgical template made in CAD/CAM technology. After another 6 months

the implants were uncovered and healing screws were introduced which enabled the proper gum formation. After a few weeks dental impressions were taken to register the position of the implants and the configuration of the soft tissues of the oral cavity.

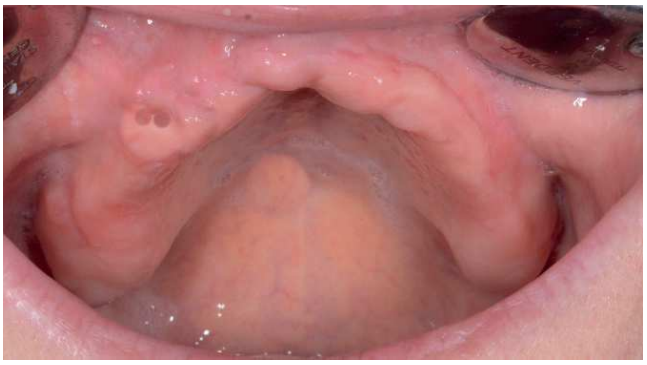

Fig. 1. Inraoral view of the situation before the treatment

2.2. Clinical and technical methodolog

The intraoral impressions were scanned with the laboratory scanner to create a virtual model of the jaw with registered position of the implants (Fig. 2).

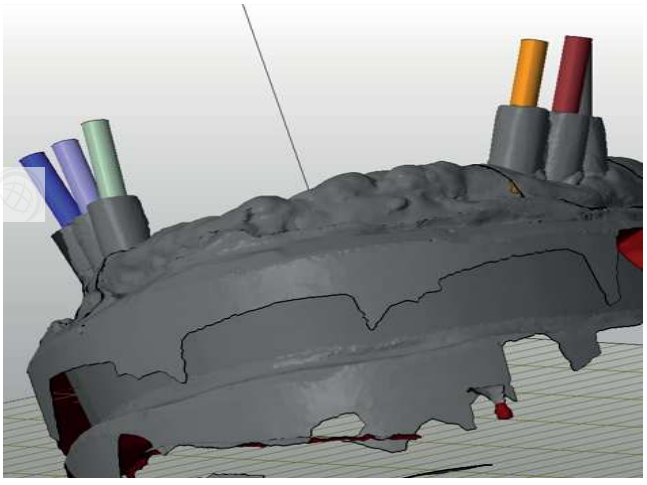

Fig. 2. The virtual model of the maxilla with the registered position of the implants

The next step was to design a ceramic substructure, which enabled the creation of the stable base for individual crowns imitating natural teeth and, on the other hand, the restoration of lost soft and hard tissues of the oral cavity (Fig. 3). It was very important to design the appropriate copings for the connection of the whole superstructure to dental implants with the abutment screws.

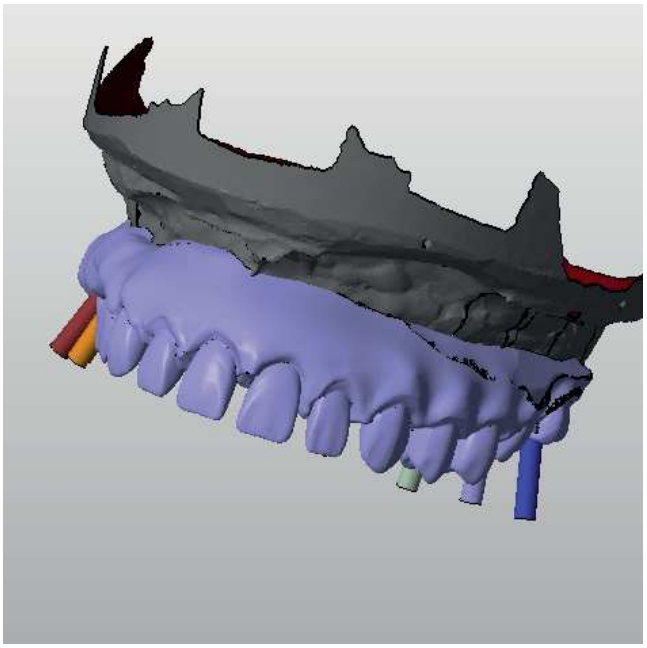

Fig. 3. Virtual model of the implantoprosthetic supra-structure restoring the lost soft and hard tissues of the oral cavity and giving support for individual crowns

Then a virtual model of the individual crowns was created. This model enabled manufacturing of individual ceramic crowns, which could be cemented on the ceramic foundation of the prosthesis (Fig. 4).

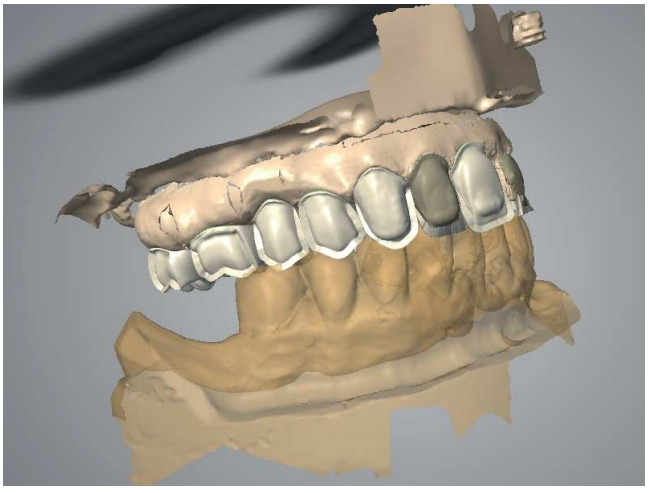

Fig. 4. Designing of the individual crowns restoring the lost dentition in relation to the opposing dentition

The substructure and the ceramic crowns were milled in a CNC milling machine out of a block of zirconium dioxide (Fig. 5). The zirconia substructure was then covered with layers of veneering ceramics. Pink ceramics has been used to mimice the oral mucosa, while the teeth have been covered with ceramic veneering in order to achieve a natural aesthetic effect (Fig. 6).

Fig. 5. The milling process of the ceramic suprastructure in the CNC milling machine

Fig. 6. The suprastructure covered with the veneering ceramics

In the inner part of the prosthesis special copings for connection with implants were designed and manufactured (Figs. 7-9). Access openings to the copings were on the surface facing the oral cavity. The holes were located at places that could be covered by individual prosthetic crowns (Figs. 10 and 11).

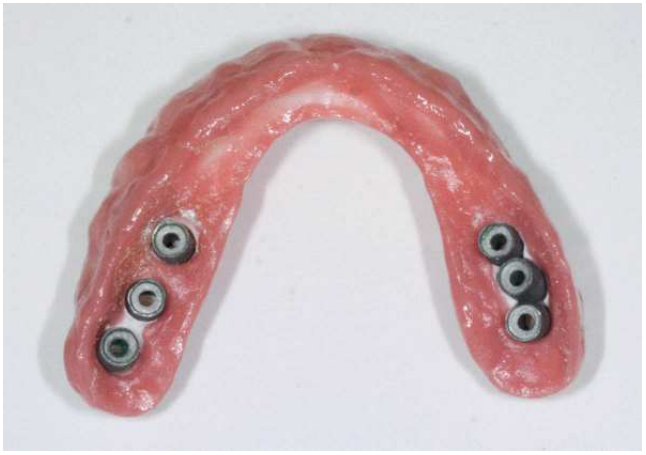

Fig. 7. Copings in the intaglio surface of the suprastructure for stable connection to the implants

Fig. 8. A lateral view of the suprastructure with individual ceramic crowns at the front region

The suprastructure was then tighten with the abutment screws to the implants and secured with hot gutta percha. Then individual crowns were cemented onto the ceramic suprastructure (Fig. 12). The final aesthetic effect is presented in Figure 13.

Fig. 9. A lateral view of the suprastructure with the copings

Fig. 10. Access openings located at the side facing the oral cavity designed to be covered with individual crowns

Fig. 11. Individual crown covering the access openings in the ceramic suprastructure

Fig. 12. Intraoral view of the suprastructure with individual crowns covering the access openings

Fig. 13. Final aesthetic result of the reconstruction of the upper dental arch

3. Discussion

To properly plan the prosthetic work rebuilding the alveolar ridge on dental implants it is necessary to plan the final prosthetic work before implant placement planning the number of implants and their location in the bones and the possibility of using a fixed or a mobile suprastructure [14]. Without analyzing the bone conditions enabling execution of the prosthetic work should primarily focus on

defining the correct occlusal relationship affecting the appearance of the face. A good solution to be used in cases of complex and extensive prosthetic work is the manufacturing of wax prototypes. This is a good solution, especially for patients who have already used prostheses. After accepting the aesthetic effect and the scope of the prosthetic reconstruction a dental technician can proceed to final designing and manufacturing of the suprastructure. The appearance of the teeth and the face is crucial for the final success [4]. A dental technician needs to know the position of the implants to hide the openings for abutment screws. Then, according to the implant position, it is possible to design the final shape of the suprastructure and the artificial teeth. At this stage, it is a very important decision to plan the copings for the implants. In the case of fixed restorations it is extremely important to design the whole structure as a one piece of a solid material. Due to the properties of zirconium dioxide it is not advisable to perform lodges for fixing screws made of ceramics, as this may result in rupture of the entire framework during screwing-in. A much more effective solution is to make the individual copings in the form of sleeves. This solution will allow for the proper and permanent attachment to the implants at the same time conducting clamping sleeve during mounting procedure [13,15].

For technological reasons it is not possible to make such an extensive suprastructure in a single piece. It is necessary to execute the foundation of the reconstruction of the alveolar ridge and the teeth in one piece and separately the individual crowns. This solution is supported by at least 3 reasons:

1. no limits in regards to the height exceeding 25 mm in one piece; the suprastructure under the study has a total of approximately 33 mm in height,
2. manufacturing of individual crowns allows to get the best aesthetic effect,
3. this solution allows for placing the access openings underneath the individual crowns.

Design of the suprastructure has to take into account the following factors:

1. the number of implants, copings and openings for the abutment screws,
2. arrangement of teeth in the prosthesis,
3. the shape of the alveolar ridge,
4. the shape of the space for the porcelain and for the individual crowns, which will be pasted on the suprastructure.

When designing such an extensive prosthetic work, in particular on implants, it is extremely important to ensure proper alignment throughout the prosthetic work. A very important aspect is to take into account the maximum occlusal forces not to exceed the mechanical strength of the materials used. The most important aspect to guarantee the maintenance of a long-lasting prosthetic work is to avoid empty spaces between the intaglio surface of the suprastructure and the oral mucosa, especially at the front region. The framework has been designed using a prosthesis made as a wax-up and less space for the porcelain.

Milling such an extensive work was required to take into account the burden of the material and the risk of its deformation in the process of sintering. Thus, it was necessary to perform an integrated substructure.

The suprastructure was covered with 6 layers of gum-colored porcelain in 4 different shades and burned in the oven in a specially developed process, taking into account the long time needed to achieve a uniform temperature with such a thick layer of the material. A slow increase in temperature (not exceeding 10 degrees per minute) was necessary as well as the fall of the temperature after the process at a similar rate. The actual vacuum was also increased by 300% compared to the procedure designed for extensive bridges.

Having manufactured the suprastructure, the individual crowns were made using the protocol for full-ceramic restorations.

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