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The use of technological documentation in vestibuloplasy fixture plate production

Uporaba tehnološke dokumentacije kod izrade fiksacijskih pločica za vestibuloplastiku

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Sažetak. ***Cilj:*** U svrhu pružanja kvalitetnije usluge bolesnicima dentalno-medicinske protetike, implementacija računalnih rješenja postala je nužan korak. Stoga je cilj ovog rada utvrditi potrebno vrijeme za izradu fiksacijske pločice za vestibuloplastiku računalnim rješenjima baziranim na CAD/CAM (engl. *computer-aided design and computer-aided manufacturing*) tehnologiji i usporediti ga s izradom fiksacijske pločice konvencionalnom metodom, uobičajenom u praksi. ***Metoda:*** Tijekom ovog istraživanja izrađene su dvije fiksacijske pločice. Jedna pločica izrađena je konvencionalnom metodom pomoću alginatnog otiska i sadrenog modela, a druga uporabom novih računalnih rješenja i CAD/CAM tehnologijom. Korištenjem obje metode analizirano je ukupno vrijeme potrebno za izradu fiksacijske pločice, kao i broj potrebnih koraka za izradu istih. Također je analizirano vrijeme potrebno za izradu i pristup dokumentaciji, te vrijeme transporta između zubotehničkog laboratorija i ordinacije dentalno-medicinske protetike. ***Rezultati:*** Uporabom CAD/CAM tehnologije osigurala se slijednost svih koraka u postupku izrade fiksacijske pločice, a računalna dokumentacija mogla se pohraniti na serveru i učiniti dostupnom širem krugu korisnika. Analizom podataka vidjelo se da je broj koraka primjenom računalne metode u odnosu na konvencionalnu manji za 18,1 %. Vrijeme potrebno za pripremu dokumentacije kraće je za 30,0 %, za pristup dokumentaciji 86,7 %, dok je vrijeme za izradu dokumentacije manje za 40,0 %. Primjenom računalne metode vrijeme transporta skraćeno je za 83,3 %. Ukupno vrijeme izrade fiksacijske pločice računalnom metodom u odnosu na konvencionalnu metodu smanjeno je za 51,6 %. ***Rasprava:*** Uporaba računalne tehnologije u odnosu na konvencionalnu metodu značajno ubrzava vrijeme rada u dentalno-medicinskoj protetici, te na taj način podiže razinu usluge.

Ključne riječi: aditivna proizvodnja, CAD/CAM modeliranje, fiksacijska pločica

Abstract. ***Aim:*** The implementation of computer applications has become a necessary step in providing higher quality service to patients receiving dental/medical prosthodontic restorations. Thus, the aim of this research was to determine the time necessary for the vestibuloplasty fixation plate manufacturing using the computer aided method based on the computer-aided design and computer-aided manufacturing (CAD/CAM) technologies, and then compare it with the conventional method, which is presently used in common practice. ***Methods:*** During this research two vestibuloplasty fixation plates were manufactured. The first one was made as per conventional method using the alginate impression and hard stone, while the other one was made using new computer aided method based on the CAD/CAM technologies. Using both methods, we analysed the total time for fixation plate manufacturing as well as necessary steps in process. In addition, access, documentation creation and transport between dental laboratory and the dental/medical office time were also analyzed. ***Results:*** The use of the CAD/CAM technologies ensures the continuity of all steps in the process of vestibuloplasty fixation plate production. Electronic documentation created in this way can be stored at a network server and become available for wider range of users. Data analysis indicates that the number of steps used in the computer based method is decreased for 18,1 % compared with the conventional method. Improvements indicate that documentation preparation time was decreased for 30,0 %, and time for documentation access was reduced for 86,7 %. Time for documentation creation was decreased for 40,0 %. This computer method also increased transport time efficiency for 83,3 %. In comparison with the conventional method, the total time necessary for fixation plate manufacure was significantly reduced for 51,6 %. ***Discussion:*** The use of computer aided method based on the CAD/CAM technologies in comparison with the conventional method significantly accelerates production time in dental/medical office thus raising the level of service.

Keywords: additive manufacturing, CAD/CAM modeling, fixture plate

INTRODUCTION

Technological innovation (TI) is a dynamic process, perhaps the most dynamic of all industrial activities[1]. The advancement of computer technology[2-5] has enabled a higher quality service to the patients receiving dental/medical prostheses. The evolution of new development environments makes it possible to create software applications for control and elaboration of plans for the biocompatible element production process. Object-oriented programming languages like C# or Java are generally easily portable to most leading operating systems. The waiting period for services of prosthodontics' component manufacture has been significantly reduced by the use of modern procedures. Moreover, better anatomical geometry has been achieved.

The current development of new materials and computer technologies allows significantly better application of computer-aided design and computer-aided manufacturing (CAD/CAM) software[6,7] in domains of analysis and manufacture of fixation plates and its implementations in the field of prosthodontics. The focus has shifted to the creation of technological documentation in order to ensure the continuity of all elements in the process. On the other hand, large numbers of samples and differing geometries represent a problem as the production process is directly dependent on the skills of a person performing the tooling manually[8]. An additional factor complicating the creation of technological documentation in prosthodontics is the disconnection between different standards in use. Furthermore, the characteristics of each plate vary presenting additional demands in planning, as shown in Figure 1.

Parallel to the development of medical services and broadening of the span of different procedures, the current method of planning and production (manual tooling and finishing) is often limited in both quantity and quality and in some cases fails to satisfy a wide range of recipients. High demands in this specialized market are emphasized by requirements of superb precision and accuracy as well as short production times.

This paper aims to make a comparison of technological documentation preparation for polymethacrylate fixture plate in vestibuloplasty using the new and conventional methods.

The implementation of computer applications has become a necessary step in providing higher medical quality. Use of computer aplications increase accuracy and significantly decrease working time. Electronic documentation created in this way can be stored on a network server and be made available to a wider range of users.

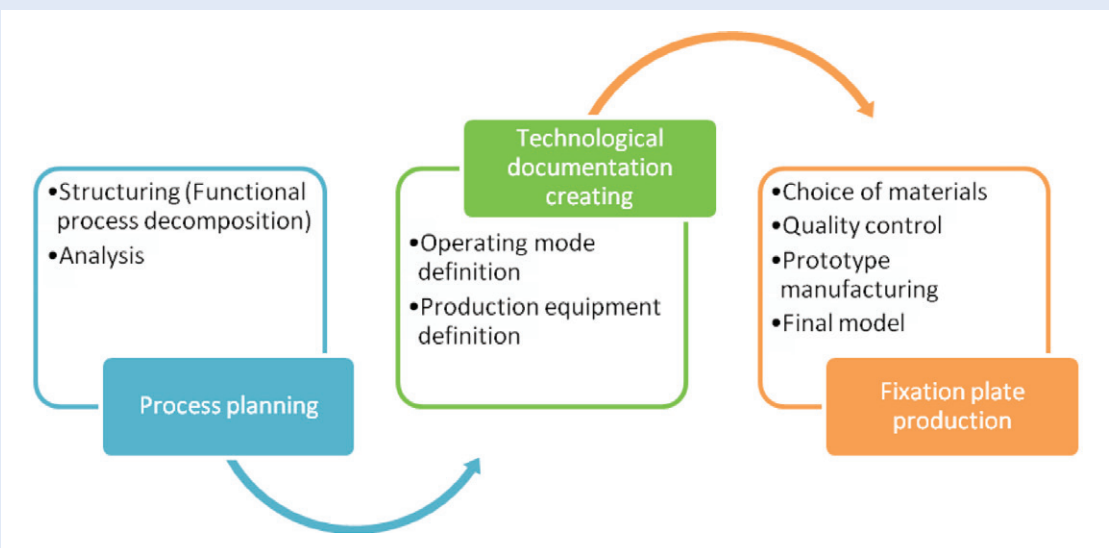

Figure 1. Development cycle of fixation plate production – process planning, technological documentation creation and fixation plate production

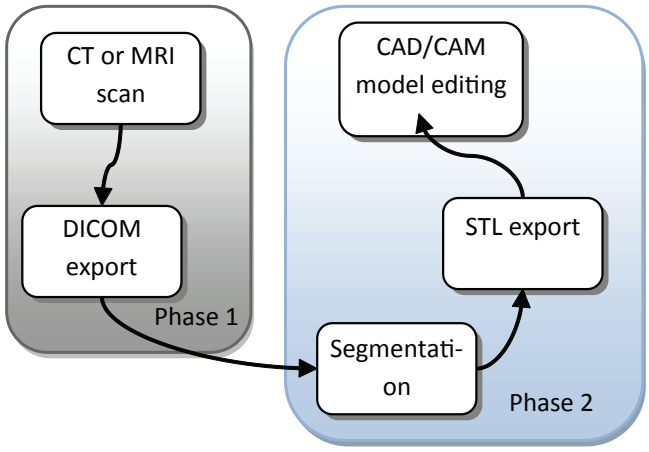

Figure 2. The reconstruction process of digital data

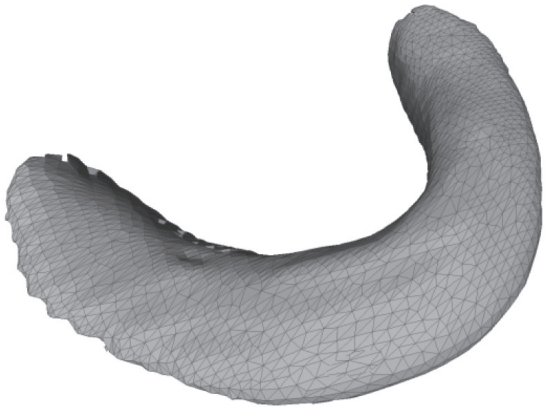

Figure 3. Fixture plate model geometry

MATERIALS AND METHODS

Two separate cases were examined during this research: one using the *conventional (common) method* of production of polymethacrylate vestibuloplasty fixture plate, which has been common in the practice, and the other one using *computer aided methods* based on the CAD/CAM technologies.

The method of the vestibuloplasty plate procedure was as follows: The extremely unfavorable anatomical conditions were determined (extreme alveolar ridge resorption). Alginate impression was obtained and sent to a dental laboratory where a cast was made in hard stone. After analysis of the alveolar ridges on a hard stone, cast boundaries for the vestibuloplasty plate were determined by a specialist of prosthodontics cooperating with a specialist of oral surgery. The cast was then sent to a dental laboratory where an acrylic plate was manufactured. This method does not provide complete differentiation between soft and solid tissue or their boundaries. The method is partially based on the experience of a technician and does not completely satisfy in regard of precision, having also a great disadvantage of time spent due to remoteness of dental laboratories. It is often necessary to adjust the fixture plate intraoperatively which also prolongs the labor time.

The other method (Figure 2) included vestibuloplasty fixed plate production using the CAD/CAM tools. After digital cross-sections had been obtained using some of the medical diagnostic machines (computerized tomography, CT; magnetic resonance imaging, MRI), data were exported into the standard Digital Imaging and Communications in Medicine (DICOM) format, segmented, analyzed and finally used to produce 3D models. The use of Additive Manufacturing (AM) enables a higher degree of integration for all participants in the planning process and the actual production. Unlike previous conventional machining methods where tool bits remove the material layer by layer to achieve the desired geometry, the rapid prototyping methods obtain the desired geometry creating it layer by layer – contrary to the conventional machining principles and conserving material in the process. Figure 3 presents a CAD/CAM model of a fixture plate showing the mesh.

RESULTS

Table 1 shows a comparison of several parameters for the cases examined. Most importantly, the number of steps was reduced by approximately 18 %, while the time necessary for documentation preparation was reduced by approximately 30 % using electronic processing. The usual method and manual production of fixture plates has namely been replaced by electronic methods. Time for documentation access was reduced for 86,7 %. Time for documentation creation was decreased for 40,0 %. This computer method also increased transport time efficiency for 83,3 %. In

Table 1. A comparison of several production parameters

		Case 1 (Classical Method)	Case 2 (Digital Method)	$\Delta_{difference}$ [%]
1	Number of steps	11	9	18,1 %
2	Documentation preparation time [min]	10	7	30,0 %
3	Average documentation access time [min]	7,5	1	86,7 %
4	Documentation creation time [min]	25	15	40,0 %
5	Model transport time [min]	15	2,5	83,3 %
			average $\Delta_{difference}$ [%]	51,62 %

comparison with the conventional method, the total time necessary for fixation plate manufacure was significantly reduced for 51,6 %. The classical method required several physical transports of the product to the dental laboratory. The electronic method allows a far greater flexibility and facilitates information sharing so that all the relevant data can be made available on a server. Due to the remoteness of the laboratory, the time of transport was integrated in the total operation time. By applying the new approach, the time of product model transport is allowed no delay as it is performed over an internal LAN.

DISCUSSION

In this paper we have shown that using the computer method significantly reduced the total time necessary for fixation plate manufacure when compared with the conventional method. Using medical diagnostic machines (CT, MRI), our data was exported into the standard DICOM formant, segmented, analyzed and finally used to produce 3D models. The process is divided into several phases. At the beginning, in the first phase it is necessary to make the digitalized data of the observed area. This is accomplished by CT or MRI scans. The vast majority of artifacts[9,10] might be created in this phase. In presented case after CT scan, export to the DICOM data format follows. In recent years, DICOM 3.0 has been increasingly used format. The newest medical diagnostic devices can work with this format. Then, the second phase follows, also called the process of segmentation. At this stage it is necessary to choose one of the segmentation techniques in order to achieve the best possible result. Selection process for segmentation technique[10] directly depends on the person who is responsible for the segmentation process. Sometimes it is necessary to combine several segmentation methods to achieve optimal results. Since most models today are designed in one of CAD/CAM computer systems, the physical remoteness of all participants does not represent a problem like it did a few years ago. The existence of a digital copy significantly facilitates the creation of detailed technological documentation. In that case, all members of the development team obtain the electronic prototype[9,10] ready for further evaluation in the shortest time. Thus achieved interactivity ensures that less time is required for product manufacture and significantly expedites the production process in comparison with the classical method.

CONCLUSION

This paper gives an overview of two different approaches in dental/medical prosthodontic restorations. Two separate cases were examined during this research: one using the *conventional (common) method* of production of polymethacrylate vestibuloplasty fixture plate, which has been common in the practice, and the other one using *computer aided methods* based on the CAD/CAM technologies. The digital method used in this study for the manufacturing of the palatal plate significantly decreased time consuming when compared with the classical method which manufactures vestibuloplasty fixed plate in a dental laboratory on a hard stone cast.

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