Journal of Production Engineering
Vol.15 No.2

Original Scientific Paper

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RE-CAD/CAM APPROACH IN DESIGN AND MANUFACTURING OF DENTAL CERAMIC CROWNS IN COMBINATION WITH MANUAL INDIVIDUALIZATION

Received: 02 July 2012 / Accepted: 22 August 2012

Abstract: *CAD/CAM technology in dentistry offers high-end ceramic restorations, known for its quality, preciseness, swiftness and repeatability. However, some features are still human-dependent. A young female patient required smile enhancement, since suffering from colour change on three devitalized frontal teeth. After fiber post placement, teeth were prepared for metal-free restoration. Consequently, abutments were scanned using extraoral scanner (Sirona, InEos Blue; Beinsheim, Germany). CAD software (version 3.8) has been used to create three crown copings, with cut-back in the incisal region. After finalization of the virtual modeling, data file has been transferred to a milling unit (Sirona, MCXL, Beinsheim, Germany) that produced crown copings out of a ceramic block (IPS e.max CAD, Ivoclar Vivadent, Schaan, Liechtestein). Crowns were tried for the fit and occlusion in the so-called blue stage, after which final strength and shape has been achieved by thermal treatment in the ceramic furnace. Individualization has been done manually, creating special effect in the cut-back region. Crowns were cemented adhesively. CAD/CAM offers modern and relevant way of producing ceramic restorations, however, special effects still require manual adjustments.*

Key words: *CAD/CAM, dentistry, extraoral scanner, computer aided inspection*

RE-CAD/CAM pristup projektovanju i izradi zubnih keramičkih navlaka u kombinaciji sa ručnim individualnim prilagođavanjem. *CAD/CAM tehnologije u stomatologiji nude visoko kvalitetne keramičke zamene, poznate po kvalitetu, preciznosti, brzini izrade i ponovljivosti. Međutim neke opcije još uvek zavise od ljudske intervencije. Mlada pacijentkinja je imala zahtev za poboljšanjem osmeha, pošto je patila od promene boje na tri prednja nezdrava zuba. Posle instalacije vlaknene podloge, zubi su bili spremni za bez-metalnu reparaciju. Otisci su bili skenirani ekstraoralnim skenerom (Sirona, InEos Blue, Beinsheim, Nemačka). CAD softver (verzija 3.8) je korišćen za generisanje tri navlake. Po završetku virtuelnog modeliranja podaci su prebačeni na glodalicu (Sirona, MCXL, Beinsheim, Nemačka) koja je izradila navlake od keramičkih blokova (IPS-a, max CAD, Ivoclar Vivadent, Schaan, Lihtenštajn). Navlake su posle isprobane zbog procene naleganja i začepljenja u tzv. plavoj etapi, posle čega je konačno očvršćavanje i oblikovanje postignuto termičkom obradom u peći za keramiku. Individualno prilagođavanje je izvršeno ručno, sa izradom posebnog efekta u zadnjem delu. Navlake su cementirane adhezijom. CAD/CAM nudi moderan i važan način u izradi keramičkih implanta ali posebni efekti još uvek zahtevaju intervenciju čoveka.*

Ključne reči: *CAD/CAM, stomatologija, ekstraoral skener, računarom podržana inspekcija*

1. INTRODUCTION

Striving towards its primary goal – primum non nocere („above all, do not harm“ eng.), the area of dental prosthetics has introduced numerous novel technologies and methods that allow the manufacture of precision, custom-made, optimal dental replacements. During the past decade, efforts have been concentrated towards an advancement of the modelling and manufacture of dental replacements by introducing advanced computer aided (CA) systems, new materials and machining technologies, as opposed to the traditional way of manual manufacture, which is prone to numerous subjective errors. Amongst modern CA systems that have found broad application in this area, the most widely used are 3D digitization systems, computer aided design (CAD) with reverse engineering (RE) and computer aided manufacturing (CAM). The development and implementation of such technologies and systems have paved the way towards a significant advancement in conventional modelling, manufacture and the inspection of dental replacements [1-5].

RE-CAD/CAM approach has been introduced in dentistry as a precise, efficient, accurate and error-free tool to produce high-quality dental restorations [1,2]. Practically, it can produce ceramic crowns in matter of hours, enabling reconstruction during single visit [3]. With the use of CAD/CAM, however, limited aesthetic results can be achieved, since individualization is still human-dependent.

CAD/CAM consists of three major parts [4,5]:

1) 3D digitization,
2) RE-CAD and
3) CAM.

Current problem with CAM unit is related to the milling process. It utilizes ceramic blocks, which are namely made out of a single material type. Further development enabled different translucency within a block, where enamel and dentin characteristics are reproduced [6]. These variations are possible within leucite blocks only. Since natural teeth exhibit variations in colour and translucency, they are hard to

reproduce with uniform blocks.

2. CASE REPORT ON APPLICATION OF RE-CAD/CAM APPROACH IN DESIGN AND MANUFACTURING OF CERAMIC CROWNS

A young female patient, 35-year's old, came into the practice requiring aesthetic enhancement of her anterior teeth. With clinical inspection, it has been concluded that left central, as well as right lateral incizors are devitalized and therefore significantly darker comparing to natural teeth. Right central incisor had a pre-existing metal-free restoration, with an active metal post reinforcement. The appointment was set in two weeks, and three metal-free crowns were planned. Interestingly, exactly on the treatment day, existing crown with the post broke. After removal of the metal post remainings, it became obvious that only dowel metal core can be inserted, due to a very insufficient dentin layer. In order to mask metal background, layers of opaquer were baked prior to cementation. Two other teeth were reconstructed with fibre posts. As a result, however, an uneven background became apparent (Fig. 1).

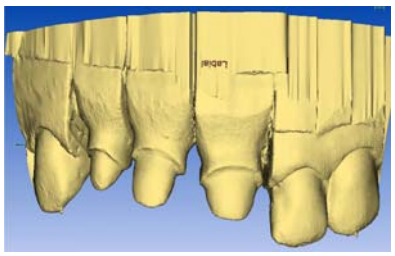
Fig. 1. Situation prior to impression taking

2.1 3D digitization

After impression taking, a dental cast model was made. For this purposes, a special, scanable gypsum was used (Fujirock EP OptiXscan, GC, Japan). Model was scanned with Cerec In Eos Blue (Sirona, Beinsheim, Germany) 3D digitization system (Fig. 2a). The scanner uses structured light (stripe projection) and has a narrow triangulation angle for deep cavities [7,8].

Blue light indicates a model part that is currently being scanned [10]. The model appears as a virtual model in CAD CEREC version 3.8 (Fig. 2b).

a) Cerec In Eos Blue 3D digitization system with the detail during the scanning process



b) The result of 3D digitization in CAD CEREC

Fig. 2. The 3D digitization system with the digitization result

2.2 RE-CAD design of dental crowns

First step in creation of virtual crowns is determination of preparation line and insertion axis (Fig. 3). Operator can choose among several possibilities, that are implicated in various morphological bases (such as young, adult, old, Asian, etc.). Consequently, proposal of the crown is created by the software (Fig. 4) [9].

Further modifications of the crowns can be done using manual tools. Once finished, crown is fixed by the software and treated as a natural tooth. Then, a contra lateral incisor is created. Initially, there is an overlap between two crowns, that can be corrected using several crown equators (Fig. 5) [11,12]. Small modifications of the crown shape can be done using manual tools such as adding, removing, smoothening etc. (Fig. 6).

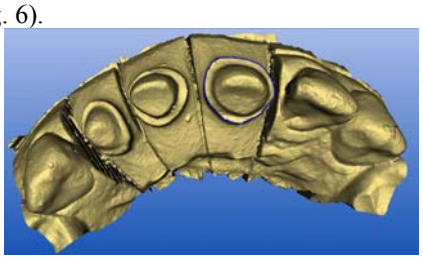


Fig. 3. Determination of the preparation line

Fig. 4. CAD model of the left central incizor

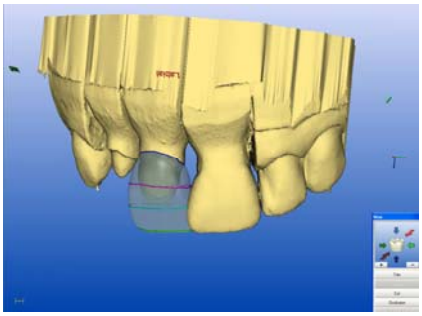


Fig. 5. Processing of the right central incizor in the CAD module

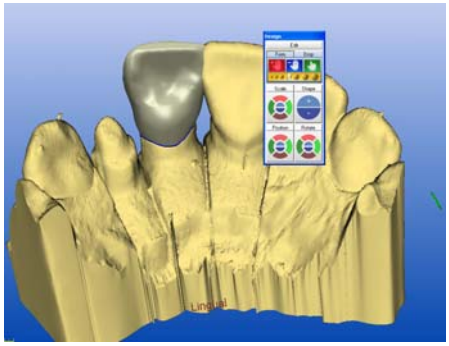


Fig. 6. Manual modification of the size and shape with specific toolbar

Major challenge is creation of cervical isthmus, that appears a consequence of uneven gingival margins. If not paid attention to, it can create disrupted optical image of central incisors, normally know to be the most symmetric teeth in the jaws.

2.3 CAM of dental ceramic crowns

When finished in the CAD, modeled crowns are proceded to CAM module (Sirona MCXL). This is a new version of the milling machine, with accuracy of 25 µm and 60% faster comparing to the previous version. Lithium-disilicate blocks were used (IPS e.max CAD; Ivoclar Vivadent AG; Schaan, Liechtenstein), exhibiting 350 MPa flexural strength (Fig. 7).

To achieve optimal translucency, LT (low translucency) block was the choice. This block enables some level of light penetration, enabling life like appearance but still covering background colour to some intent.

CAM unit mills in a so-called blue block stage, where both hardness and strength of the material are not fully achieved (meta-silicate stage). Since blue blocks do not support stock milling (milling of multiple units out of a block), three C14 blocks were used. After milling and initial trial, blocks were crystalized in a ceramic furnace (Programat P300, Ivoclar Vivadent AG; Schaan, Liechtenstein).

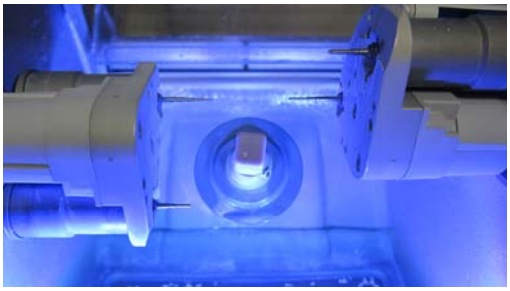


Fig. 7. Cerec CAM unit with blue lithium-disilicate block

2.4 Manual individualization of dental ceramic crowns

Milling, however, is the final stage in current possibilities of the CAD/CAM systems, in regards of individualization. Any further characteristics have to be done manually.

Individualization can be done using two basic techniques:

1. layering and
2. staining.

Layering creates in depth, profound esthetic appearance. It, however, requires significant technical skills.

Staining is used as a toll to modify optical impression by superficial colouring of the restoration. In this case, both techniques were used. Fig. 8 presents the application of layering technique with ceramic powders, while the application of staining technique with ceramic stains is shown on Fig. 9.

Fig. 8. Application of the layering technique with ceramic powders

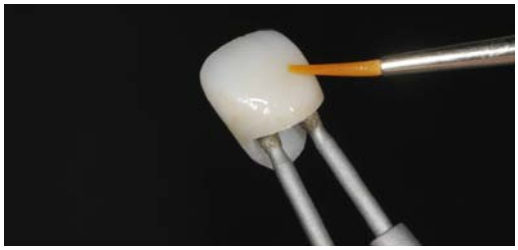


Fig. 9. Application of staining technique with ceramic stains

The other issue that cannot be solved with CAD/CAM systems only is background colour coverage. LT ingots still transmit light in a sufficient manner, that enable background colour influence if thickness of the restoration is not more than 1 mm. To predict this unwanted effect, background colour is simulated in the lab by the special die composite (Fig. 10). Therefore, the determination of the final esthetic result is still human-dependent. Finished restorations are shown in Fig. 11.

Fig. 10. Final colour modifications on a special composite die

Fig. 11. Final restoration

3. CONCLUSION

CAD/CAM in dentistry is a unique approach, that improves classic treatment procedure. Through 3D digitization, it transfers real teeth into digital information, that can be processed into virtual objects within the specialized RE-CAD software. With the support of data bases with predefined teeth shapes, the software creates restoration automatically. However, manual control is enabled as well. CAM is a highly-sophisticated manufacturing procedure, with high accuracy and time saving.

Within this paper, an case report that comprises all three stages of dental CAD/CAM approach – 3D digitization, RE-CAD modelling and CAM manufacture – has been presented. However, esthetic factors, such as individualization, colour features, effect of the background and final appearance are still human dependent. That is why the special attention in this paper is focused on this stage that includes activities for further automation.

ACKNOWLEDGEMENT

A part of result presented in this paper is obtained in the framework of the project *"Research and development of modelling methods and approaches in manufacturing of dental recoveries with the application of modern technologies and computer aided systems"* – TR 035020, financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

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