Eur. J. Prosthodont. Rest. Dent., Vol.22, No. 4, pp 159-165
Printed in Great Britain

doi:10.1922/EJPRD_1279Nicolas07

Ceramo-Metal Crown or Cad-Cam Rehabilitation: Patient and Practitioner Appraisal

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Abstract - *Crowns produced using CAD-CAM technology must be evaluated so they can be integrated in the dentist's therapeutic arsenal. To this end, an evaluation tool for the fixed element units was developed and tested in a randomized cross-over pilot study. At a hospital centre, 10 single crowns from the same dental preparation and produced using CEREC technology were compared to Ceramo-Metal Crowns produced using a conventional procedure. Practitioners generally evaluated CEREC crowns more positively, corroborating the subjects' preference for these crowns. The CEREC technology used in a hospital setting meets the requirements of both patients and practitioners.*

KEYWORDS: Cad-Cam, Cerec, All Ceramic Crown, Ceramo-Metal Crown, Evaluation

INTRODUCTION

The mechanical properties of the Ceramo-Metal Crowns used traditionally ensure their stability and give satisfying aesthetic results. So far, they have been considered as the gold standard of functional and aesthetic rehabilitations. However, the broad scope of these crowns is limited in terms of biocompatibility[1] and bio mimicry, which can hinder the quest for an optimal aesthetic crown that best matches the natural aspect. In the literature, the limitations associated with these crowns are usually described as follows: barrier to light transmission, opaque stain, and gingival coloration[2,3]. These problems are worsened during the reconstruction of the maxillary incisors. Indeed, the "smile teeth" are especially exposed and expert eyes can detect the smallest imperfection.

For the past thirty years, many advances have been made in the field of dentistry, mainly with the introduction of new materials and techniques[4,5]. Although feldspathic ceramic crowns were commonly used with jacket crowns, their fracture rates were higher than those for Ceramo-Metal crowns, thus preventing the development of all-ceramic technology[6]. The improvement of the mechanical properties of ceramics and progress in the bonding procedure has led to their use for the rehabilitation of anterior teeth without a metallic frame[7].

Studies focusing on these ceramics demonstrated good mechanical properties, improved quality of the dental-crown joint and better aesthetics.

Simultaneously, advances concerning adhesion techniques ensured reliable adhesion of ceramic material to dental tissues and in particular to enamel. Dentine adhesion is due to the infiltration of resin in dentine tubules and by the formation of a hybrid layer (penetration of adhesive into the collagen fibre). Thus, the cohesion of the crown preparation has further improved the mechanical properties of the assembly[8,9]. Adhesion was shown to increase mechanical resistance by distributing occlusal loads[10]. Furthermore, the adhesive procedures were simplified, with fewer steps, self-adhesive and sometimes self-etching resin cement. At the same time, aesthetic requirements were better met with adhesive post and core reconstitutions using post-resin fibre rather than metal post and core reconstitutions, thus removing the greyish effect of metal[4,11].

The development of CAD-CAM technology, especially CEREC, has led to new perspectives in the way we work with and use ceramics. Using CAD-CAM technology provides many advantages such as the preparation of a prosthetic unit in one session, fewer communication problems with the prosthetic laboratory, and, in the case of "conventional crowns", better stability, reliability and precision of these prosthetics[12].Depending of the local economic of the medical system, CAD-CAM technology could sometimes reduce costs (no need for impression material, or dental technician). Nonetheless, the question remains as to whether all ceramic crowns derived from CEREC have sufficient aesthetic qualities to constitute a real alternative to traditional Ceramo-Metal Crowns, especially when it comes to the restoration of the maxillary incisors.

In an attempt to answer this question, a specific evaluation tool designed to compare the aesthetic qualities of both types of crowns was used. Cvar and Ryge (2005)[13] designed a tool to evaluate dental restoration material. These authors evaluated the aesthetic qualities of different types of restorations based on predefined criteria. This tool was also used and adapted in two other studies that compared All-Ceramic Crowns produced with CEREC with other types of crowns[14,15]. However, crowns could only be compared by taking into account an overall appreciation rather than each of their various aesthetic components. It would therefore be of interest to highlight these differ-

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ent aesthetic criteria within the evaluation. Each criterion should be evaluated independently for each type of crown. Hence, the strong points and weaknesses of each restoration could be detailed, making it possible to bypass the subjective sensitivity of practitioners regarding a particular aesthetic criterion.

The main objective of this study was to develop an evaluation tool and use it to compare All-Ceramic Crowns produced using CEREC with traditional Ceramo-Metal Crowns (CMC), both used on maxillary incisors. This study also focuses on an additional question, that of which aesthetic components should be considered as important?

MATERIALS AND METHODS

Study design

The study was designed as a randomised prospective, double-blind, cross-over pilot study (Figure 1).

It was performed by two practitioners, namely a final year dental student (junior practitioner), and a teacher of the Clermont-Ferrand Dental School (senior practitioner), University of Auvergne.

Study progress

The study was performed within the dentistry unit of the Clermont-Ferrand University Hospital (France). 8 subjects underwent prosthetic treatment for one or 2 teeth of the maxillary incisors (6 subjects with one tooth to be rehabilitated and 2 subjects with 2 teeth to be rehabilitated). All the patients were over 18, were able to understand the scope of the study and were not subject to bruxomania. Their oral hygiene and periodontiums did not hinder the final aesthetic or functional results. The course of the study was explained to each participant who then signed a consent form.

For each tooth requiring a single fixed dental prosthetic rehabilitation (a total of 10 teeth), one Ceramo-Metal Crown and one all Ceramic (Cerec) Crown were prepared. Each tooth was prepared according to the preparation standards for all ceramic crowns: specific preparation respecting the periodontium with a margin line including a rounder inner edge shoulder, located most often in the paramarginal area, and with a thickness of at least 1 mm at the cervical margin and 2 mm at the incisal margin[16].

The Ceramo-Metal Crown was prepared from polyvinylsiloxane impression materials. The ceramic shade requested was determined using Vitapan Classical® shade guides, in accordance with the shade of the other anterior maxillary teeth. The tooth colour measurement device, EasyShade, was used to confirm the practitioner's choice. The complete crown and ceramic joint were then ordered from the prosthetic laboratory. Simultaneously, a numerical impression was performed using the CEREC IV Sirona® device. Numerical data were immediately processed and the prosthetic element was obtained in the same session, using the CEREC milling units. The crowns were prepared in leucite-reinforced glass ceramic blocks: IPS Empress CAD (Ivoclar Vivadent®) blocks available in HT (high translucency), LT (low translucency) or multi (opacity gradient, natural translucency). The hue of the ceramic blocks used was determined in the same way as that of the Ceramo-Metal crowns. After processing, the crown was adjusted in the mouth of the patient, both functionally and aesthetically, before performing the final steps of external make-up (when necessary) and then glazing.

Each crown was fixed alternatively and at random with temporary cement. After one week, the first crown was evaluated by both examiners and the patient. The investigators were unaware of the type of crown they were evaluating. Subsequently, the first crown was replaced by the second one, which was also left in place for one week and then evaluated as previously. At the end of this two-week period, the patient had to choose the crown they would like to keep. The ceramo-Metal Crowns were permanently fixed with glass ionomer cement while all-ceramic crowns were fixed with self-adhesive resin cement.

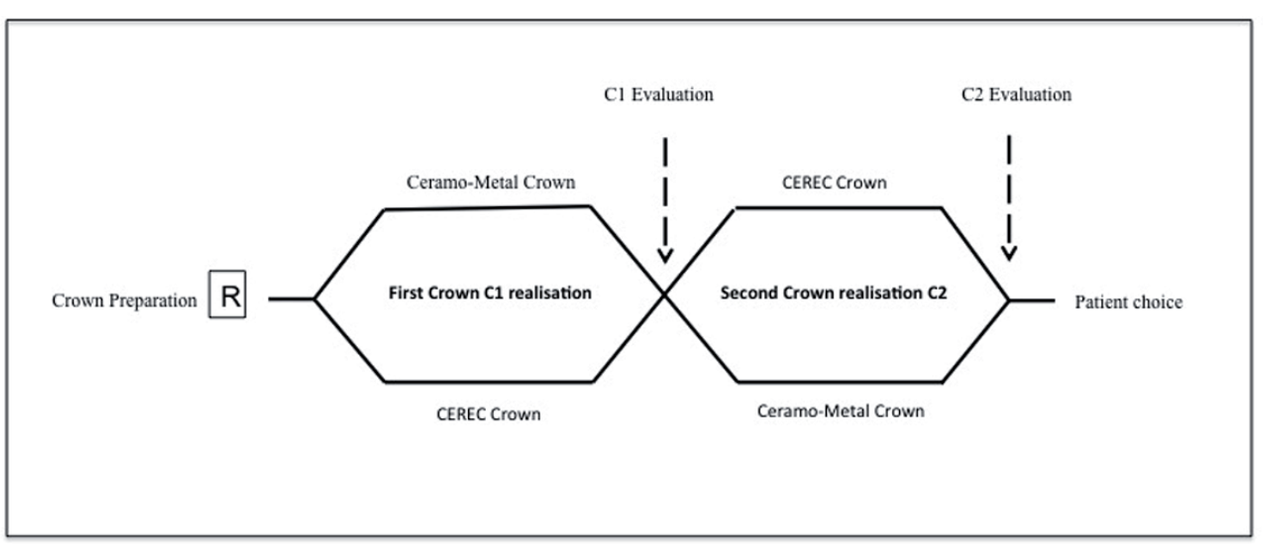

Figure 1. *Study design: following the crown preparation, which was given a random order « R », a Ceramo-metal or all ceramic (Cerec) crown (C1) was temporarily fixed for one week and evaluated independently by two examiners (junior and senior) and by the patients. Subsequently, the second type of crown (C2) was fixed temporarily and evaluated in the same way. Finally, according to the patients' choice, the selected crown was permanently fixed.*

The evaluation tool used by the practitioners

The main goal of the evaluation tool was to compare the aesthetic results obtained with different types of single crown. Therefore, certain criteria applied for all the anterior teeth, such as smile symmetry, were excluded from the questionnaire. Similarly, certain aesthetic criteria, such as periodontal design regularity, could be influenced by the pre-prosthetic treatment. These criteria, for which the final result was not solely related to the crown, were also excluded from the questionnaire. Nine aesthetic items were selected from former studies[17,18]. The practitioner was asked to evaluate each prosthetic preparation according to each of the following items using a Visual Analogical Scale (VAS; 0 to 10, 0 = Low, 10= Good).

Item 1: "Crown morphology"

Item 2: "Crown space position": This encompasses the "principal dental axis", "integration in the dental arch ", "smile line" and "lip standing"

Items 3, 4, and 5 were related to crown colour. This criterion was divided into 3 distinct categories: 3 "Chroma", 4 "Value", and 5 "Hue"

Item 6: "Surface finish"

Item 7: "Ceramic characterization"

Item 8: "Marginal limit and periodontal integration"

Item 9: "Occlusion, function"

The evaluation tool used by the patients

The evaluation questionnaire for patients was designed according to the criteria mentioned above, but simplified and adapted to facilitate its comprehension by them. For example, Item 1 of the patients' questionnaire defined as "crown colour", included the 3 distinct categories of "Chroma", "Value", and "Hue" from the practitioners' questionnaire. Furthermore, the satisfaction level of the patient was evaluated. An additional item defined as "global satisfaction level" was included in the patients' questionnaire. Each item was evaluated using a VAS. At the end of the questionnaire, the patients were invited to select the crown they would like to keep (Item 10).

Item 1: "Crown colour"

Item 2: "Crown shape"

Item 3: "Crown dimension"

Item 4: "Dental integration" (compared with the nearest teeth)

Item 5: "Periodontal integration"

Item 6: "Crown function"

Item 7: "Crown comfort, surface finish"

Item 8: "Smile harmony"

Item 9: "Global satisfaction level"

Item 10: "Which crown would you select?"

Data collection and analysis

Statistical analysis was performed using the SPSS 20 software (SPSS Inc., Chicago, IL). For each type of crown, the possible mean score difference between the junior and senior practitioners' evaluations was studied using the Student paired t-test (α=0,05). The impact of the type of rehabilitation (Cerec or Ceramo-Metal) on the Practitioners' score was tested by repeated-measure analysis (variable: Cerec or CMC Score; fixed variable: criteria of evaluation). The possible impact of the type of crown on the Patients' evaluation score was analysed in the same way. The possible interaction between the Cerec and the CMC score was tested using the Pearson correlation.

RESULTS

Irrespective of the type of crown evaluated, the mean evaluation score of the junior practitioner was better than that of the senior practitioner ($p<0.001$). Regardless of the examiner (practitioner or patient), the Cerec evaluation score was better than the CMC evaluation score ($F=68$; $p <0.001$) (Figure 2). However, score differences were criterion-dependent ($F=3$, $P<0.05$) (Figure 3) and subject-dependent ($F=12$, $p<0.001$). Regarding the patients' evaluation, (Figure 4), the Cerec score was higher than the CMC score ($F=16$, $P<0.001$), irrespective of the criteria (Figure 5). This difference varied according to the subjects ($F=8$, $P<0.001$). A positive correlation between the Cerec and the CMC score was obtained ($\rho=0$ .22, $p<0.05$). As for the decision regarding the type of crowns to keep in place, 8 patients chose the Cerec crowns while two chose the Ceramo-Metal crowns. Moreover, 5 patients chose the crown best ranked by both practitioners, and 5 patients chose the crown best ranked by the junior practitioner alone.

DISCUSSION

The aim of this study was to evaluate the functional and aesthetic integration of single prosthetic units. More often than not, Cerec crowns were favoured compared to traditional Ceramo-Metal crowns.

The aesthetic approach was limited in this study because of the population chosen. Indeed, patients treated in the dental hospital unit usually require substantial care, and they are not primarily concerned by aesthetic. To evaluate the aesthetic aspect, a standardised sample presenting oral characteristics closer to the basic aesthetic criteria[19] would be required. Therefore, in the present study, the oral state of each subject was taken into account, possibly explaining the fact that the results obtained were subject-dependent. Furthermore, only one or two teeth, and not the entire anterior maxillary sector, were rehabilitated. The basic aesthetic criteria, such as smile symmetry, teeth alignment, and smile line, would have been easier to evaluate if the entire anterior sector were restored[20]. Indeed, rehabilitation of the smile can be improved when all of the anterior teeth are restored using the same materials and the same type of restoration[21]. This was clearly not the case in the present study, where sample crowns had to be integrated alongside natural teeth, other Ceramo-Metal crowns or treated teeth. Moreover, Ceramo-Metal crowns were not prepared by a professional ceramic dental technician, although dental technicians from the hospital were able to prepare good quality standardised crowns. This was also true for the CEREC crowns. The ceramic make-up was shown to be closely linked to the success of the aesthetic integration[14]. Similarly, the colours available for the Cerec ceramic blocks did not always match the desired colour[22].

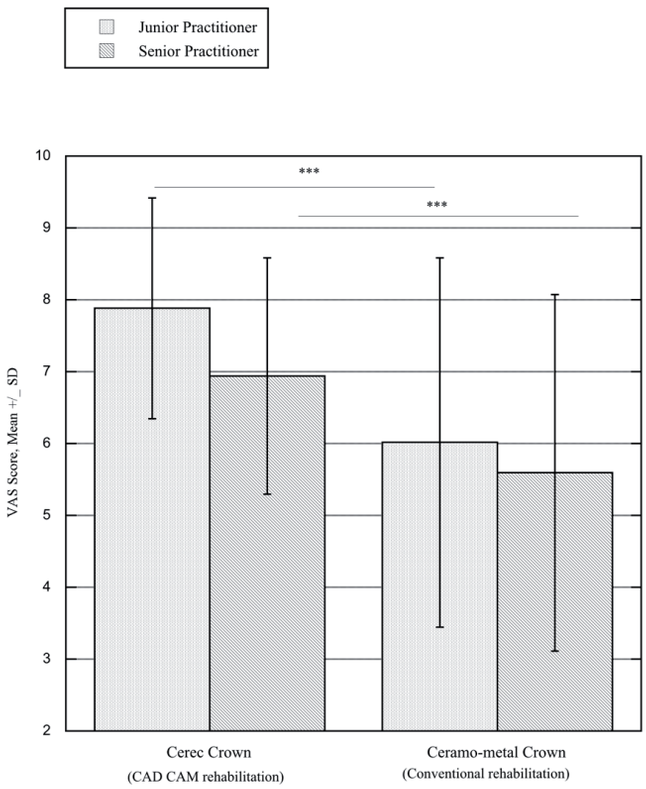

Figure 2. *The evaluation score of the junior and senior dental practitioners according to the type of crown. Irrespective of the type of rehabilitation, a better score was obtained for the evaluation of the junior practitioner (p<0.001) and for the Cerec crown (p<0.001)*

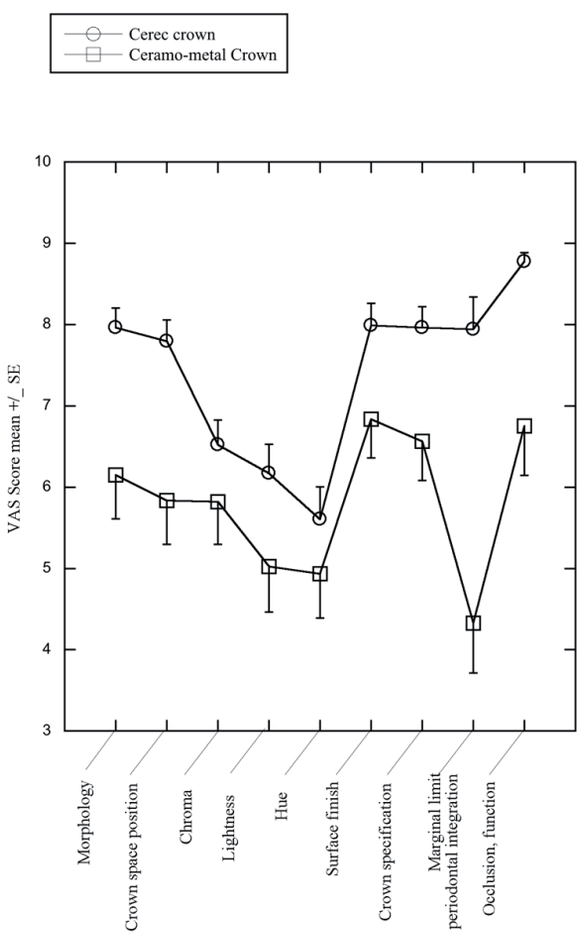

Figure 3. *Mean score for the evaluation of both practitioners for the Cerec and the CMC crowns according to each criterion*

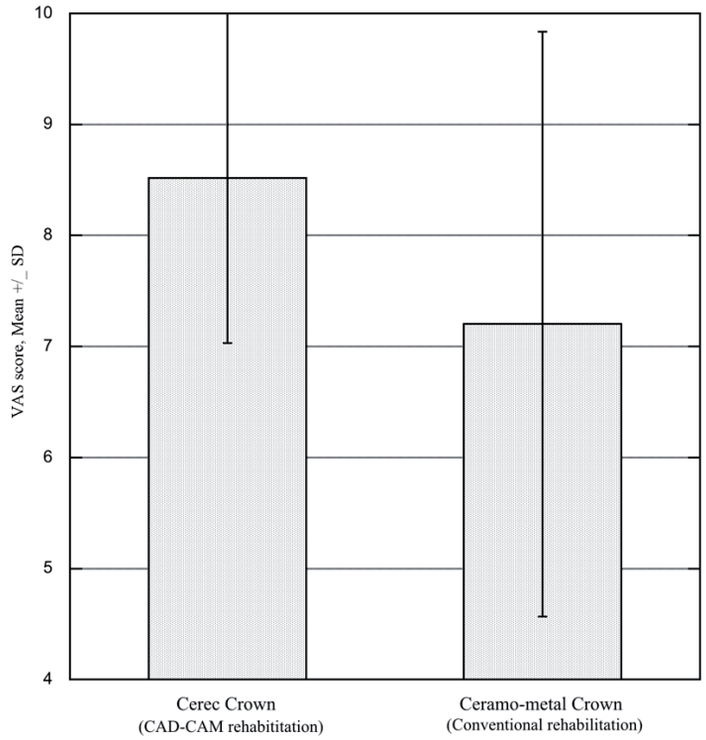

Figure 4. *Patients' mean evaluation score of the Cerec and CMC crowns*

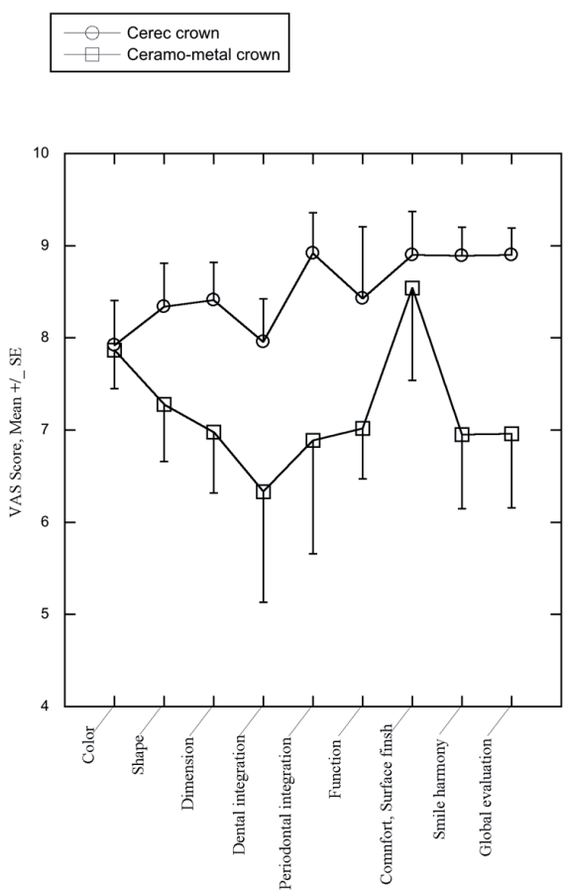

Figure 5. *Patient's mean evaluation score of the Cerec and CMC crowns according to each evaluation criterion.*

Taken together, the results showed that patients preferred CEREC crowns compared to Ceramo-Metal crowns. This outcome corroborated that of the examiners. However, for 5 out of the 10 subjects, only one of the examiners, more often than not the junior practitioner chose the same crown as the subjects. These findings are in accordance with a study from Brisman (1980)[23], which concluded that there is a statistical difference between evaluations from patients and practitioners, and that aesthetic evaluations by dental students often match those of patients and practitioners. These observations remind us of how unique aesthetic perception is to each individual[24]. Some subjectivity remains, irrespective of the evaluation tool used. Indeed, each individual is unique with their own expectations, aesthetic references and culture[25]. The beauty of a smile is therefore very different from one individual to another. Practitioners must deal with these notions in order to fully satisfy their patients.

It appears that the choice of the senior (and more experienced) practitioner diverged far more considerably from that of the patients, probably as a result of a more thorough aesthetic evaluation. However, the criteria they paid most attention to were not necessarily the same as the patients'[26].

Similarly, this study showed that differences observed between Ceramo-Metal and Cerec crowns were subject-dependent. However, the CEREC technology uses a more translucent ceramic. Some authors [4,27-29] insisted on the fact that the nature of the post and core, the type of adhesive, and the thickness of the ceramic are all important in choosing the type of ceramic to be used. For example, obtaining a satisfying aesthetic result is challenging when using a metal post and core, since choosing the colour of the CEREC ceramic block remains difficult. Indeed, using a relatively translucent adhesive to set a CEREC crown on a metal post and core can lead to the development of a greyish colour at the marginal limit[30]. Therefore, that crown could lose its translucency under poor lighting or be more noticeable within social distance.

In order to resolve this problem, it was necessary, while preparing CEREC crowns, to thicken the ceramic, and to use a ceramic with more saturation, a denser (opaque) adhesive, and a post and core varnish[27]. Both patients and practitioners then seemed more satisfied. Previous studies[2,3,27,28,31-34] have presented similar results and underlined the impact of the type of supporting tooth, the thickness of the material and the final hue of the cement chosen for the ceramic crown. In particular, a real difference was shown between the colour chosen and that obtained when combining the various parameters[2]. It is therefore difficult to predict the aesthetic result and obtain a restored tooth of natural appearance.

CONCLUSION

This work supports other studies on the ability of Cerec crowns to match the aesthetic qualities of traditional Ceramo-Metal crowns and replace them, particularly in the case of maxillary incisor restorations[35,36]. A restoration concept seems to be emerging around CAD-CAM technology that favours saving dental tissues and adapting restorations, such as the endocrown procedure without peripheral preparation. In this respect, CAD-CAM technology could revolutionise the basic concepts of conventional prosthetics[37]. In addition, CAD-CAM technology is a powerful educational tool, through which each user can improve their skills according to the difficulties encountered and the results obtained; its use in universities is of great interest as the application of learning tools combined with monitoring technological innovations is one of their central objectives[38].

ACKNOWLEDGEMENT

The authors wish to thank Caroline Eschevins and Accent Europe for their help in writing the English version of this manuscript.

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