

Extra-oral assessment of conventional and CAD-CAM complete denture appearance by dental professionals and CRDP wearers: A randomized survey

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ABSTRACT

Introduction: Complete removable dental prostheses' (CRDPs) appearance may vary between conventional and contemporary CAD-CAM manufacturing techniques.

Objectives: The aim of this randomized survey was to analyze appreciation of CRDPs, manufactured with different techniques, by dental professionals and elder CRDP wearers.

Methods: Four participant groups, comprised of undergraduate students (n=10), postgraduate residents (n=10), dental technicians (n=10) and elder CRDP wearers (n=10), evaluated the appearance of maxillary CRDPs manufactured by six different techniques: three conventional methods 1. flask-pack-press (FP), 2. Injection-molded (IM), 3. intrinsically colored natural gingiva finish before injection-molded (NG) and three CAD-CAM methods 4. milled base with bonded prefabricated teeth (M), 5. fully milled including milled teeth (FM) and 6. rapid-prototyped including printed teeth (P). A randomized, blinded survey included 18 pairwise comparative assessments and 12 individual judgements of the CRDPs on general appearance as well as pink and white aspects. Statistical analyses included parametric- and nonparametric tests as well as linear regression models; the level of statistical significance was set at $p < .05$.

Results: NG was preferred by the professional groups but not by the elder CRDP wearers ($p < .05$). P was scored lowest by all four participant groups ($p < .05$). CRDP wearers' ratings were less severe and within a narrower range. The ratings of the two CAD-CAM milled CRDPs (M and FM) were ranked closer to FP and IM; the order of preference was different depending on the participant groups.

Conclusions: The findings of this study revealed marked differences in the assessment of CRDP appearances between dental professionals and older CRDP wearers.

Clinical significance: A shared and informed approach to decision making concerning the CRDP appearance might foster denture acceptance and treatment success.

1. Introduction

Dental esthetics have been gaining increasing attention and importance in the recent decades. Interest is driven by the patients and fueled by the media as teeth and their contribution to overall appearance have become recognized as part of enhancing personal appearance [1]. The greater focus on dental esthetics has therefore infiltrated the various

dental disciplines as dentists look to address the current day esthetic expectations [1, 2].

Complete removable dental prostheses (CRDPs) are a specific area of dentistry where this heightened interest in dental esthetics can be employed to its maximum potential and effect [3]. The esthetic aspect is a recognized factor in patient expectations to and acceptance of CRDPs [4–7], so it is helpful to offer input on the various parameters of CRDP

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esthetics. Restoration of the appearance of edentulous patients has received limited attention [8, 9], although the psychological burden and functional impairment of tooth loss may vary between patients, there is general agreement that they are important [10, 11]. Therefore, some dentists and technicians have turned highly customized dentures into an artform [9]. Whether the objective is to replicate the natural characteristics as closely and realistically as possible or to provide an idealized smile, the means for achieving both the white and pink esthetic aspects exist. The esthetic quality and characterization of prefabricated denture teeth have improved remarkably as have the techniques and materials for mimicking gingival tissues. With careful attention to try-in of the set-up of teeth and soft tissue profile and contouring in the clinic together with custom finish in the dental laboratory, astonishingly lifelike prostheses can be achieved. The aim of a natural and age-appropriate appearance is to allow the edentulous person to keep the fact that they are wearing a removable prosthesis private. This is often referred to as “prosthetic or dental privacy” [12]. Customization of dentures requires both, time and skill and is likely to impact on cost and availability. In the findings of a qualitative study, there is support for suggesting that customization would also be appreciated by the patients [13].

Comparing professional and patients' perception of need for esthetic dental treatment to the natural dentition, the literature suggests that patients judge the need to be higher than the dental professional [2]. However, there are also reports that patients' perception of the esthetics of their smile is higher than dentists' opinions [14, 15]. The common factor between these reported findings is that there are likely to be differences between the patient and dentist opinions on dental esthetics. The initial evaluation of the patient's preferences and expectations may foster the acceptance of the treatment outcome [8, 16].

The CAD-CAM manufacturing techniques for CRDPs have steadily been gaining popularity. Clinically acceptable results are reported for both of the two principal techniques, the subtractive milling [17, 18] and the more recently additive rapid prototyping (RP) also known as 3D printing [19, 20]. Comparison between CRDPs manufactured by CAD-CAM milling and those constructed with conventional techniques, demonstrate similar or better fit of the intaglio surfaces, equal biocompatibility, and improved mechanical properties [21–23]. Patient satisfaction with CAD-CAM fabricated CRDPs is also reported to be similar to conventional CRDPs [24].

Whereas satisfactory comfort and function has been documented for CAD-CAM manufactured CRDPs, to the knowledge of the authors, no study to date has addressed appreciation of their overall appearance or distinguished between their white and pink aspects. With appearance as an important factor in patient acceptance of CRDPs and in particular of the maxillary denture [4, 5, 7], evaluation of this aspect of the CAD-CAM types is therefore both important and relevant as is their comparison to conventional CRDPs.

With the potential differences between opinions of patients and dental professionals and the increasing emphasis on inclusion of patient-reported outcomes measures [25], it is also logical to explore opinions of both groups.

Therefore, the aim of this study was to evaluate and analyze the opinions of dental professional groups and elder denture wearers regarding appearance of CRDPs fabricated by six different manufacturing techniques.

2. Material and methods

This non-interventional, quality control randomized survey did not require approval from the ethics committee as it did not involve any patients, patient-related data or biological samples.

2.1. Study design

The study was divided into Part 1, a pairwise comparative

assessment and Part 2, where CRDPs were rated individually (Table 1).

In Part 1, the participants were given a set of 12 CRDP specimens and asked to make a total of 18 comparisons based on pre-determined randomized pairings. The first 15 pairings ensured a comparison of each of the six CRDP types against the other five. For reliability of method, the remaining three were mock trial comparisons of identical FP, NG and FM (Fig. 1). The participants were asked to indicate their preference towards one denture or the other for each of six questions using a horizontal visual analogue scale (VAS) regarding six criteria: 1) general appearance of CRDP teeth, 2) shade of CRDP teeth, 3) detail of CRDP gingiva, 4) shade of gingiva, 5) design of palate, and 6) overall/global CRDP preference.

The midpoint of the 10 cm long VAS scales line served as a point of no preference and accordingly an allocated score from -5 to 5 indicated which side CDRP was preferred and to what extent. The measurement was recorded at the nearest millimeter. Participants had the opportunity to provide comments. All the study participants made the same 18 comparisons, but in a different randomized order.

In Part 2 of the study, the participants were asked to rate individually the 12 CRDPs; two for each manufacturing group. The questionnaire used a numerical scale from 1 (lowest) to 10 (highest) scores for a total of 10 parameters. Of those, five related to the white esthetics of the CRDP teeth (shape, natural appearance, surface detail, contours, shade/transparency) and five related to the pink esthetics of the gingiva imitation in the CRDP bases (shape, natural appearance, detail, transition to teeth, shade).

2.2. Study sample/participants

The study recruited 40 participants in four groups, 1- undergraduate students (UG) 2- postgraduate residents in a prosthodontic specialization program (PG), 3- dental technicians (DT) and 4- elder CRDP wearers (DW). There were no further inclusion criteria for UG, PG and DT groups. For the DW group, participants were only included if they were non-dental persons, aged 70 years or older, and were rehabilitated with a maxillary CRDP.

Table 1
Outcome parameter for Part 1 and Part 2

Part 1 (comparison between two specimen)	
Please judge the appearance for each pair of CRDP specimen on a VAS scale	
Q1	General appearance of prosthetic teeth
Q2	Color of prosthetic teeth
Q3	Finish of gingiva
Q4	Color of gingiva
Q5	Design of palate
Q6	Overall preference
Part 2 (individual judgement of specimen)	
Please judge the appearance each specimen on a numerical scale from 0 to 10	
Regarding the prosthetic teeth	
Q1	Form
Q2	Natural appearance
Q3	Surface detail
Q4	Contours
Q5	Color / translucency
Regarding the denture body / artificial gingiva	
Q6	Form
Q7	Natural appearance
Q8	Surface detail
Q9	Transition to prosthetic teeth
Q10	Color

		IM	NG	M	FM	P
FP	X	X	X	X	X	X
IM			X	X	X	X
NG			X	X	X	X
M					X	X
FM					X	X
P						

Fig. 1. Overview of the 18 pairings with 15 CRDP comparisons and 3 mock trials.

2.3. Study specimens

To allow more than one study participant participating at a time, a total of sixty maxillary CRDP specimens were fabricated from a single master model with an ideal set-up of teeth. The CRDPs were produced in sets of ten using six different manufacturing techniques: 1- conventional flask-pack-press (FP) using heat-polymerizing resin (Ivoclar ProBase, Ivoclar Vivadent AG, Schaan Liechtenstein), 2- injection molding (IM) using the Ivocap™ technique (Ivoclar Vivadent AG) with a modified polymethylmethacrylate (PMMA) resin (Ivobase High Impact, Ivoclar Vivadent AG) 3- customized finish with a multi-colored nature mimicking gingiva (NG) with a shading by a salt and vinegar technique for addition of color tones (Schottlander Enigma Color Tones, Schottlander, Letchworth, UK) prior to finishing of the remainder of the NG denture in heat cured resin (Ivobase pink veined resin, Ivoclar Vivadent AG) by an injection moulding process, 4- milled based with bonded teeth (M) (AVADENT™, GDS, Global Dental Science Europe BV, Tilburg, The Netherlands), 5- CAD-CAM fully milled including milled teeth (FM) (AVADENT™) and 6- rapid-prototyping (P) (NextDent B.V., Soesterberg, Netherlands) (Fig. 2.). The artificial denture teeth used in the CRDPs groups (FP, IM, NG and M) were identical: anterior teeth mold - PhysioStar NFC+ mold 664 and posterior teeth mold - Bonartic II NFC+ mold 04 (both Candulor AG, Glattpark, Switzerland). The shades of the teeth in IM, NG and M was A3, and A4 color was selected for the

FP group. The teeth mold used in the FM and P groups were identical and their shade was A3. The custom finish of the gingival aspect in NG included detailed contouring and intrinsic staining shading for imitation of the characteristics and appearance of natural gingival tissues. The gingival aspect of FP and IM were hand finished following to a standard approach.

2.4. Randomization of study specimens

Six blocks of 10 random numbers each were generated for the 6 CRDP groups by an online randomizing software (www.randomizer.org). The CRDP specimens were labelled accordingly with a unique number via an adhesive sticker, and the allocation was concealed and blinded to the participants. Next, five sets of 12 CRDP study specimens were collated, comprising a pair of specimens from each of the six CRDP groups. These five sets of 12 CRDP study specimens were used an equal number of times each across the four participant groups UG, PG, DT and DW.

2.5. Protocol

Ten participants were recruited for each of the four study groups. The recruitment of participants and completion of the questionnaires was organized and supervised by a single investigator (NK) in groups of no



Fig. 2. A-F (from right to left). Examples of the specimens produced by the six different manufacturing methods: Conventional: A. Flask-pack-press (FP), B. Injection Molded (IM), C. Customized finish (NG) and CAD-CAM: D. Milled base with prefabricated, bonded teeth (M), E. fully milled (FM), F. Rapid-prototyped (P).

more than 5 participants. First the participants received detailed information about the experiments, studied the questionnaires and had their questions clarified. A training sheet for the use of the VAS scale was administered, where participants marked 25%, 80%, 10%, 45% and 75% of the scale. Then, each study participant received a pre-prepared set of 12 CRDPs. Participants and supervisor were blinded to the manufacturing techniques of the specimens. A total of 40 questionnaires, each with 18 comparisons of CRDP pairs and 12 judgements of individual CRDPs were completed. The outcome parameters are listed in Table 1.

2.6. Statistical analysis

The comparisons in the five appearance questions (Q1, Q2, Q3, Q4 and Q6) in Part 1 were analyzed as both, absolute preference of one CRDP type over the others (Q6), and extent of preference as indicated on the VAS of a given type over each of the other 5 CRDP types. For the latter, the average value of the 5 VAS comparisons for each question was analyzed.

Concerning Part 2, for each question, the average of the ratings of the 2 CRDPs of the same type for each of the 10 questions were calculated. White (Q1-Q5) and pink (Q6-Q10) rating scores were obtained by averaging the answers to Q1-Q5 and Q6-Q10, respectively. The overall rating for each CRDP was analyzed as the average for the Q1-Q10 scores.

For Part 1, the distribution of the extent of preference scores did not follow a normal distribution according to a Kolmogorov-Smirnov test. All comparisons were performed using a Kruskal-Wallis test followed by the Dunn-Bonferroni adjusted post-hoc test, to show homogenous subset based on rank.

Answers to VAS questions of Part 2 were normally distributed. The influence of CRDP types, gender, and groups, on the ratings were analyzed using a linear regression model. Difference between CRDP types and groups were further analyzed using the Tukey pairwise comparison post-hoc test. Violation of homogeneity of variance was tested according to Levene's test. Correlation coefficient were computed using Spearman Rho coefficient for Part 1 and Pearson coefficient for Part 2.

The significance level was set at $p < .05$. Statistical analysis was performed by a biostatistician (PM) using a statistical software (SPSS version 25.0, IBM Corporation).

3. Results

3.1. Participants

Forty participants distributed into four groups (UG age=25.1±4.6 years; PG age=32.7±2.7 years, DT age=51.8±11.6 years; DW age 75.3±4.0 years) participated in this survey. The number of men and women was equal in each group, except for DT where 8 men and 2 women participated.

Table 2

Most preferred CRDPs according to the participant's group (Q6). 1 = most often preferred; 6 = least often preferred; *ranked equally often.

Participant groups	Ranking preference (1= most often preferred; 6= least often preferred; *-indicates equally often)					
	1	2	3	4	5	6
Undergraduate students	NG	M	IM	FM	FP	P
Postgraduate residents	NG	IM	M	FM	FP	P
Dental technicians	NG*	IM*	M*	FM	FP	P
CRDP wearers	M	FM	FP	IM	P	NG

FP: Conventional flask-pack-press; IM: Injection-molded; NG: Custom finish; M: Milled base with bonded teeth; FM: Fully milled; P: Rapid-prototyped;

3.2. Reliability of method

The accuracy of marking specific values on a 10 cm visual analogue scale (25%, 80%, 10%, 45% and 75%) was high (interquartile range (IQR) 0.5 cm). The dental technicians and CRDP wearers were significantly less precise than the undergraduate and postgraduate students (Kruskall-Wallis $p < .05$), the maximum median difference was 0.1 cm (IQR 0.6).

In the mock trial comparisons of two identical CRDP types (FP, NG and FM), the recorded scores were consistently close to the reference midpoint of the VAS scales (median 0.04 cm, interquartile range 0.05 cm) but outliers occurred in all groups of up to 0.48 cm. Gender of the participant and type of CRDP did not influence the results of the mock trial. The only difference was detected in DW who were significantly less accurate (Kruskall-Wallis $p < .01$) with a maximum median difference of 0.1 cm.

3.3. Part 1: Preference of denture type

3.3.1. Ranking of the 6 CRDP types

In undergraduate students and postgraduate residents as well as dental technicians, the CRDP that was the most often globally preferred over the others was NG (Q6). In contrast, the DW ranked NG last ($p < .05$). Preference for P occurred only in the DW group and was never preferred against any other CRDP type by any of the other groups (Table 2).

3.3.2. Extent of preference

As for the extent of the global preference (Q6), P was the least preferred, followed by FP and FM (Fig. 3). There was no difference in the extent of preference between IM, M and NG, which were the most preferred CRDPs (Kruskall-Wallis $p < .01$). These CRDP types were those that had pre-fabricated teeth in color A3. For dental technicians, the FM was equivalent to the 3 best rated CRDPs. However, for CRDP wearers, P and NG were similarly disliked while there was no clear preference given to any of the 4 other CRDPs.

Analysis of the general appearance of the teeth (Q1) and the finish of the gingiva (Q3) preference scores indicated a similar trend to the global (Q6) score with Rho correlation coefficients of 0.78 and 0.84, respectively (Figs. 4, 5). The correlation between Q1 and Q3 was lower (rho 0.64) but still significant (all $p < .01$).

For the extent of general tooth appearance preference, P obtained the

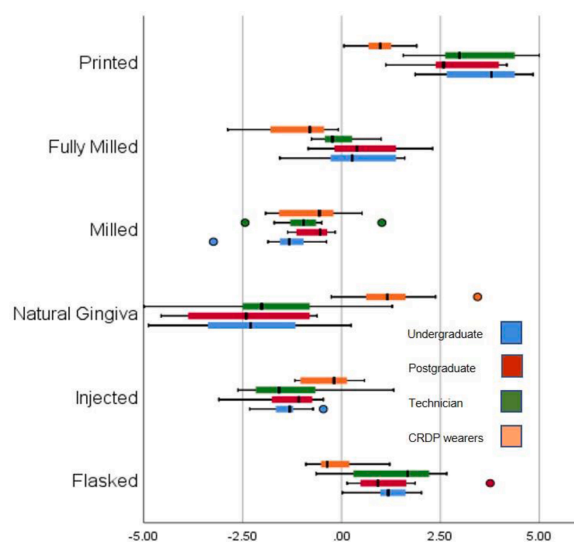


Fig. 3. Box plot of global preference scores (Q6) per participant group (-5 highest preference, 0 no preference, 5 lowest preference).

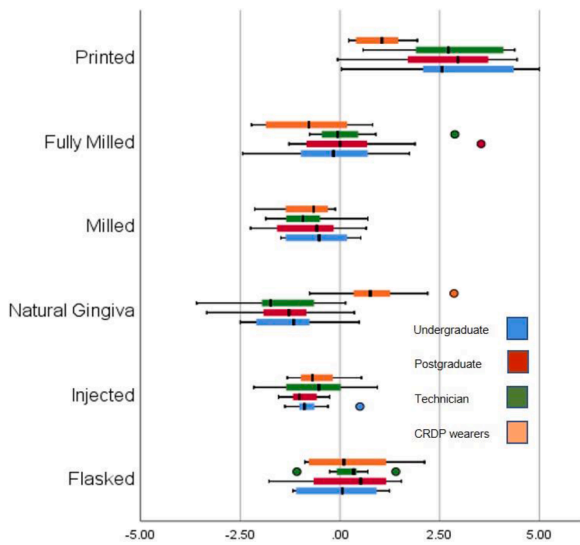


Fig. 4. Box plot of white preference scores (Q1) per participant group.

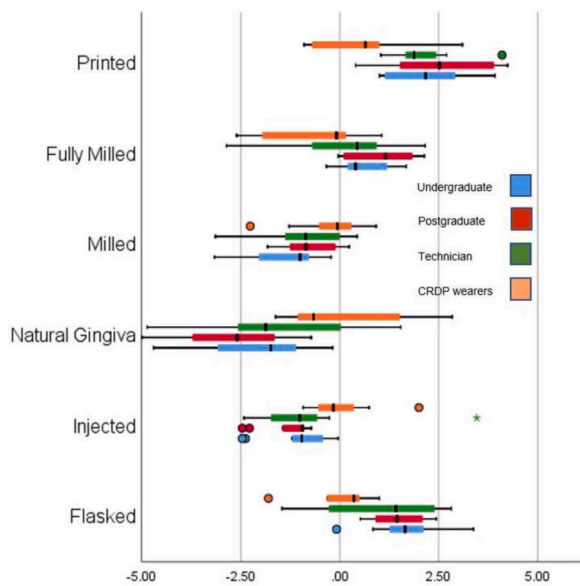


Fig. 5. Box plot of pink preference scores (Q3) per participant group.

lowest score (Kruskall-Wallis $p < .01$), with the CRDP wearers being the least severe in their judgement (Fig. 4). There were no significant differences between IM, NG, M, FM and FP. For tooth color (Q2), P was evaluated the worst ($p < .05$) and the prefabricated teeth in shade A3 of IM, NG and M the best (n.s.). For CRDP wearers, the tooth appearance of IM, M and FM were similarly preferred, whilst NG and P were the least preferred.

The gingiva finish scores (Q3) were ranked in the following sequence NG, M, IM, FM, FP and as the lowest preference P (Fig. 5). Of these, only M and IM were not statistically different from each other. The color of the gingiva (Q4) was evaluated as follows: best rated IM and NG (n.s.), followed by M ($p < .05$); FM and FP were similarly considered as the second worst, while P obtained the worst evaluation ($p < .05$). For the gingiva finish, undergraduates evaluated from best to worst: NG, then IM and M similarly and finally FM, FP and P ($p < .05$). Postgraduates evaluated also NG as the best in gingiva finish while FP, FM, and P were similarly the lowest ($p < .05$). Dental technicians agreed with postgraduates for these two evaluations. For CRDP wearers, there was no statistical difference in preference of the gingiva finish for any of the

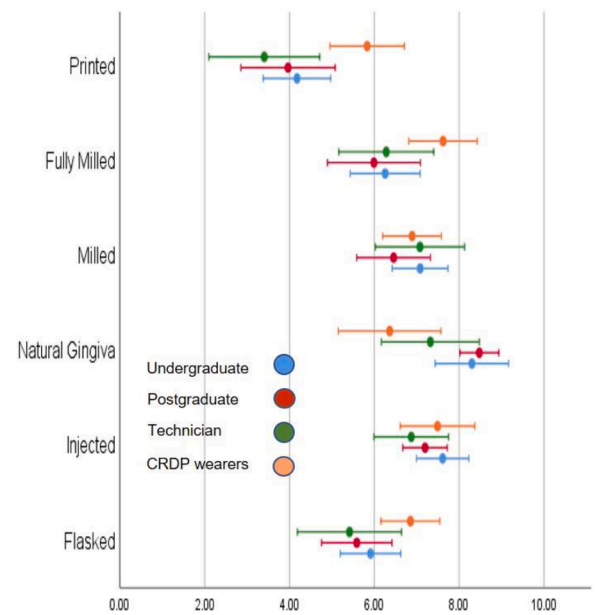


Fig. 6. Overall ratings per CRDP type (mean Q1-Q10), per participant group

CRDP types.

NG showed the largest range of scores both within participant groups and between them (Fig. 4, 5).

3.4. Part 2: Individual assessment of CRDP

3.4.1. General appreciation

For the general appreciation (mean of Q1-Q10), NG received the highest rating whereas P had the lowest scores. However, NG ratings were not statistically significantly different from IM and M (Fig. 6). Again, the three CRDP types with pre-fabricated light shade teeth were ranked best. The ratings for FP and FM were similar but significantly lower ($p < .01$) than obtained for M. Undergraduates and postgraduates ranked similarly with P the lowest and IM and NG the best (ANOVA $p < .01$).

For dental technicians P was rated significantly worse, but all the

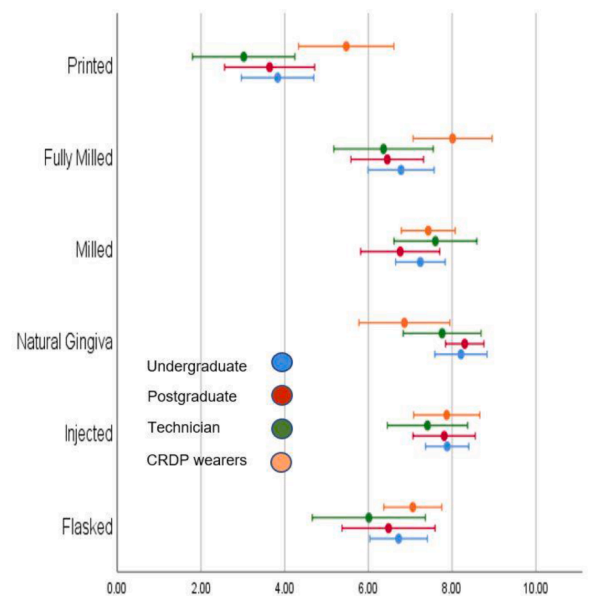


Fig. 7. White rating scores (mean Q1-Q5) for CRDP group, per participant group

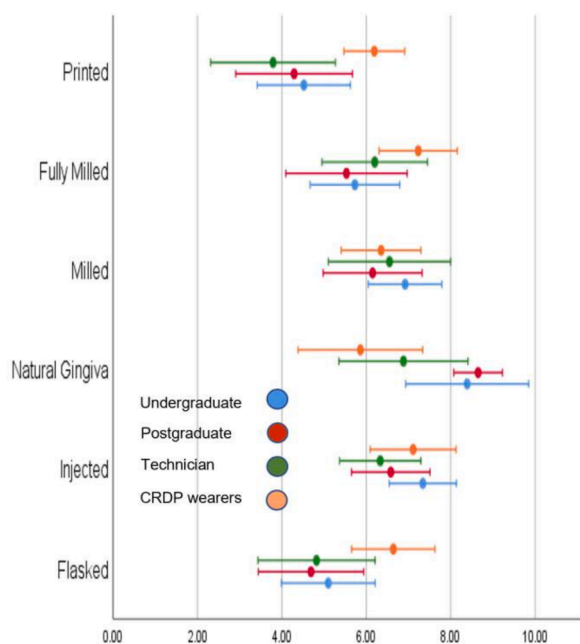


Fig. 8. Pink rating scores (mean Q6-Q10) for CRDP group per participant group

other CRDPs were rated similar (ANOVA $p < .01$).

CRDP wearers rated P as the worst, although they were less severe in their judgement than the dental professionals. P was followed by NG, FP, M, IM, FM but the differences between these 5 CRDP types were not significant. The range of their ratings was smaller than the one of dental professionals.

3.4.2. White and pink rating scores

Generally, the white (Q1-Q5) and pink (Q6-Q10) rating scores were confirming the overall ratings (Figs. 7, 8). The Pearson's correlation coefficient between the white and pink rating scores was .671 ($p < .001$). This value was high enough to consider the two scores similar, but not redundant.

For the white rating score, in all groups of participants, P was rated significantly worse than all the other CRDPs ($p < .01$). All participant groups pooled, the ranking of the CRDPs according to the white rating score was, from best to worst, NG, IM, M, FM, FP, P (Fig. 7). This ranking was also found with the pink rating scores but here P was not different from the next two worst ratings FP and FM (Fig. 8).

Undergraduates, postgraduates, and dental technicians agreed on this ranking for white and pink rating score (ANOVA $p < .01$). CRDP wearers provided a different ranking for white rating score: from best to worst FM, IM, M, FP, NG, P ($p < .01$). Yet they rated all the CRDPs similar for the pink rating score. NG obtained the most widespread range of ratings both within participant groups and between.

3.5. Modifying factors

According to the general linear regression model, gender of the participants had no significant effect on the ratings of the CRDPs in Part 2, while the factors "CRDP type" and "participant group" were highly significant ($p < .01$).

3.6. Free comments from the participants

Nine participants made entries in the free comment boxes. Four commented on recognizing identical CRDPs in the mock trials. Two participants mentioned their preference might change dependent on the patient's age and whether they were smokers or not. Two comments referred to the difficulties of cleaning when too much contour detail was

added. Further single comments included 'far too opaque tooth shade (P)', 'very nicely individualized (NG)', 'very natural rather than more beautiful (NG)', 'darker tooth shade is ugly (FP)' and 'prefer lighter tooth shade (other CRDPs versus FP)'.

4. Discussion

The study design implies certain strengths and weaknesses, which are important to consider before interpreting the results. First, the CRDPs to be evaluated were not judged in a clinical setting. They were held by the participants rather than observed inserted in a patient's mouth. However, an extraoral appreciation of a prosthesis by dental professionals always precedes the insertion into any mouth. Dentists are more used to extrapolating from a hand-held CRDP to the clinical context compared to a laboratory-based technician who only occasionally gets to see their work in the mouth. The CRDP wearers in the study were included, because they had experience seeing (at least their own) CRDPs both, in and outside the mouth.

Another shortcoming of the study design is that no information was given to the participants as to whether the CRDP was designed for a patient who desired a natural age-adequate or rather a light and stereotype appearance. This lack of information prompted one participant to add a comment of "An age-adequate "natural" dental appearance may not always be considered "beautiful".

By design, each group had a different mean age and it was therefore not possible to analyze the influence of age on preference scores and ratings. However, the age differences reflect the standard clinical situation where professionals of working age provide removable prostheses for older edentulous patients.

This study did not find that gender had any significant influence on the perception of CRDPs. As a specific gender difference in dental esthetics, women are attributed with greater ability for discerning shades [26]. For this study, the shade of the teeth was similar for all the dentures except for conventional FP. Hence, the sample size might have been too small to confirm any effect.

A strength of the study design was the standardized, identical prescription of the specimens. With the different materials and manufacturing methods used, subtle divergences occurred in morphology, tooth position, surface texture, translucency and color of the teeth and the denture body. In fact, the aim of this study was to evaluate the participants appreciation of these subtle differences. Fully identical dentures were evaluated within the 3 mock comparisons, confirming the methods used. The custom-made questionnaire included ability to distinguish between pink and white score. This allowed separating the influence of the artificial teeth and the gingiva part of the CRDP on the global assessment. Another strength of the method was to force the participants to choose between pairs of CRDPs, which invited them to discriminate, rather than rating overly positive, also described as acquiescence bias [27]. The included mock-trials in Part 1 and the analysis of the mean value of two ratings in Part 2 further validated the methodology. Fatigue was excluded as bias by presenting the CRDPs in a randomized order and by limiting the total time of the survey to 45 minutes.

There was a marked difference in the judgement of CRDP appearance between the dental professional groups and the CRDP wearing elderly laypersons. Overall, the laypersons' judgements were less discriminative and severe. Since undergraduate students and postgraduate residents judged very similar, the undergraduate training in CRDP manufacturing may already guide the judgement to preferring dental craftsmanship. Laypersons such as CRDP wearers, in contrast, lack this professional view and may have their judgement rather guided by their own looks with their "false teeth" and/or comments and reactions of their social environment after insertion of their CRDP.

There was a similar remarkable agreement across all groups and in both parts of the study to dislike P. It was mainly the white esthetics that was rated significantly worse than the other CRDP types, suggesting that

future improvements should focus on the parameters of better tooth color, translucency and surface detail, although CRDP wearers were less severe in their judgement of the printed CRDPs. The dental professional groups esteemed the pre-fabricated light CRDP teeth (NG, IM and M) higher than the milled, printed or darker shade ones. Fabricating CRDP teeth is a skilled art that comprises multiple layering steps of high-quality resins and a meticulous quality control by the manufacturers before delivery. To date, neither printing nor milling CRDP teeth from mono-colored resin seem to come near to their appearance.

The darker tooth shade used in the conventional FP attracted low scores from all four groups. It was interesting, however, that the results for the FP pink esthetics followed the white esthetics. This could suggest that the distinctly darker shade of the teeth negatively influenced the opinion of the gum finish. This would fit with the two dentist groups' appreciation of the gingival work conversely influencing their perception of the CRDPs' teeth to the point of detecting positive differences even though they were identical to the teeth used in IM and M. It would appear that the architectural frame provided by the more natural looking gingival finish enhanced the characteristics of the pre-fabricated tooth mold and shade. The dental technicians also demonstrated appreciation albeit to a lesser extent than the dentists. By contrast, the CRDP wearing laypersons may not have perceived the overall effect of the customized gingival finish as an esthetic advantage. The gingival finish appeared to even negatively influence the patients' perception of the white esthetics. The CRDP wearers' overall (preference and judgement) evaluations supported a primary focus on the white esthetics and lesser sensitivity about the finish of the gum work. Since the participating CRDP wearers had experience in daily life with wearing a prosthesis, they would know that the teeth show whereas the gingiva mostly does not.

All three professional groups globally preferred the NG whereas the patients never preferred the NG, not even against the P; however CRDP wearers ranked P in the global assessment of Part 2 as worst. This disagreement between profession and patients was a very interesting and an essential finding, which may have a major impact on clinical decision making. A patient's poor CRDP acceptance may be irreconcilable with the practitioner's appreciation of providing a skilled imitation of natural gingiva.

The lack of agreement concerning the appreciation of the CRDPs appearance suggests that the profession cannot necessarily assume that their skill and effort employed in replicating nature in a highly customized CRDP will be appreciated by the patients. As expected, the laypersons judgements were less discriminative, covering a smaller range of scores than in the dental professional groups. This is particularly important when additional cost is involved in creating the customized gingival appearance, but no corresponding perceived benefit for the patient is obtained. The appreciation of NG may vary enormously from one individual to the other; hence ascertaining the expectations out of each patient may avoid disappointment of the patient, the practitioner or both. Patient input during the CRDP construction process appears to be important for establishing patient appreciation as well as obtaining full, informed patient consent and avoiding rejection [28]. In a patient centered approach, the clinician should guide the patient with their professional knowledge regarding CRDP appearance and its impact in a social context but the final decision should be taken by the patient. A group of dentate elders were asked about their preferences in relation to dental appearance in the event of future need of tooth replacement with CRDPs. Two thirds of dentate elders responded that they would prefer a natural age-appropriate look similar in appearance to their present dentitions if they needed tooth replacement whereas only one third indicated preference for ideally formed immaculate rows of teeth [13].

Demonstration of examples of the future result including both, the tooth and gingival aspect may assist the decision process. A recent study on perception of pink gingival porcelain color highlighted the absence of standardized gingival color guides on which to base selection of shades

and detail [29]. The answer to standardized guides to gingival options for removable CRDPs could be in the form of actual specimens as seen in Fig. 1. It could also be in the form of images of tooth and gingiva options portrayed within and outside of the oral context. The contemporary use of photographs and video in clinical practice could also be beneficial to allowing patients a more holistic and realistic opportunity to assess the appearance in private away from the dental setting and to seek opinions from family and friends.

It is promising for the emerging potential of the two CAD-CAM milled CRDP types and the advantages that they offer, that all four groups could agree that their appearances were broadly in line with those of a standard finish of conventional flask-pack-press and injection molded CRDPs. In terms of expediency of manufacture and for both interim and longer-term solution for this older age group, it was also interesting that the patients seemed to be less sensitive to differences between pre-fabricated and individually milled teeth.

5. Conclusions

The findings of this study revealed marked differences in the assessment of CRDP appearances between dental professionals and older CRDP wearers. Appreciation of CRDP esthetic craftsmanship and customization of the gingiva is very prevalent in dental professional groups, but not necessarily shared by patients. A shared and informed approach to decision making concerning the CRDP appearance might foster patient acceptance.

Declaration of Competing Interest

The authors declare no conflict of interest, the study was entirely funded by institutional funds from the University clinics of dental medicine Geneva, Switzerland.

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