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RESEARCH

A comparative evaluation of masticatory efficiency and satisfaction with different types of removable partial dentures: a pilot crossover randomized study

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Aims: This study evaluated the subjective experience of masticatory performance and masticatory efficiency in partially edentulous patients rehabilitated with three different types of removable partial dentures (RPDs).
Materials and methods: This was a crossover randomized study, which was carried out at the prosthodontics clinic of the University of Ghana Dental School clinic. Sixteen patients requiring RPDs but had never worn one before were consecutively recruited for the study. Three different RPDs [i.e., cobalt chromium, acrylic, and thermoplastic resin (iFlex)] were fabricated for each patient. Masticatory efficiency was assessed using a single-sieve method after chewing raw carrots. The subjective experience of masticatory performance was also assessed using a questionnaire after 1 week of using each denture.
Results: The cobalt-chromium denture recorded the highest masticatory efficiency (31.4%), and the iFlex denture recorded the lowest (27.9%). Subjectively, the cobalt-chromium denture was ranked as the denture they were most satisfied with when chewing with the least being the acrylic denture.
Conclusion: Despite the fact that the iFlex, flexible denture had an overall appeal, where effective chewing is of great concern to prospective RPD patients, the cobalt-chromium denture may have a slightly better advantage.

Keywords: masticatory efficiency, removable partial dentures, acrylic, cobalt chromium, flexible denture

Introduction

The system functions to grind food into tiny particles to increase the surface area for effective digestion and prepare it for swallowing. When teeth are lost, there is reduced masticatory ability that can have an impact on an individual's food choices and nutritional status in the long term (1). The restoration of an efficient and functional masticatory system is therefore one of the vital aims of prosthetic rehabilitation in dentistry.

Removable partial dentures (RPDs) are a low-cost and conservative option for restoring missing teeth in partially edentulous patients. Functionally, an RPD should restore missing teeth to result in an efficient masticatory function where the patient is able to chew efficiently and comfortably and also swallow safely without interference. This will ensure proper digestion of food and the absorption of vital nutrients (2).

Effective masticatory function, food acceptability, and oral health-related quality of life have been observed to be significantly improved with the provision of new RPDs (3). This improvement in masticatory performance with RPDs has been observed when the assessment has been carried out both subjectively and objectively (3). Notwithstanding

this, RPDs have some inherent limitations as natural tooth replacements, and the masticatory function of denture wearers has been observed to be poorer than that of subjects with natural dentition (4). Bessadet et al. (5) concluded that they do not fully re-establish the masticatory function.

Several types of RPDs are currently fabricated for partially edentulous patients. They are made of either polymethyl methacrylate (acrylic) or cast metal alloys, e.g., cobalt chromium or injection-molded thermoplastic resin materials (such as iFlex). These different types of RPDs might, however, result in different chewing capabilities. Vozza et al. (6) reported differences in bite forces when using these RPDs. It is, however, not clear which of these dentures will provide a better improvement in masticatory function.

Masticatory function among patients with RPDs can be assessed using a variety of objective and subjective methods. While questionnaires help to assess an individual's subjective responses on their chewing ability with dentures, (2) chewing tests enable one to objectively assess masticatory efficiency. To predict an individual's ability to chew efficiently with RPDs, dentists cannot rely only on subjective responses to questionnaires on satisfaction with and on chewing difficulties with dentures. This is because the subjective assessment of masticatory function, when compared with functional mastication tests, is often overrated. An objective test of masticatory performance can, however, provide useful information on partially edentulous subjects wearing dentures. This information could be useful in supporting decisions made by dentists on patients' treatment plans and treatment outcomes.

Currently, evidence shows that rehabilitation of the partially edentulous individual with RPDs significantly improves masticatory performance and efficiency (7). What has not been established, however, is the outcome of the different types of RPDs on masticatory efficiency. Furthermore, the degree of satisfaction with mastication using the different dentures may vary among patients. Considering that some differences may exist between an individual's subjective evaluation of satisfaction with mastication and an objective assessment, this study sought to carry out a within-subject crossover study to compare the subjective experience of masticatory performance and masticatory efficiency among partially edentulous patients wearing the three different types of RPDs (i.e., acrylic, cobalt chromium, and iFlex by TCS).

Methods

Study design

The study was a cross-over randomized study carried out at the Prosthodontics Clinic of the University of Ghana Dental School (UGDS) in the Korle-Bu Teaching Hospital, which is a Primary referral center in Ghana. All the laboratory stages of the study were carried out at a private dental laboratory (Advocate Dental Laboratory).

Study population, sample size, and sampling

Participants were sampled from the pool of dental patients who attended the Dental Clinic of the UGDS. Sixteen partially edentulous patients attending the clinic requiring RPDs but had never worn any form of RPDs before were consecutively recruited for the study using a purposive sampling approach. Four belonged to each of the four Kennedy's classifications of partially edentulous arches, and eight each belonged to the maxillary and mandibular arches. A minimum sample size of 13 was estimated using standard statistical criteria ($\alpha = 0.05$ and $\beta = 0.20$) for a minimum expected difference for statistical significance as 10 mm on a 100-mm Visual Analog Scale (VAS) with a desired power of 80% and significance criterion = 0.05 and a variance of (SD) (2), based on a previously determined standard deviation of 14.1 mm for this type of study using a VAS (8). Three patients were then included–two to account for dropouts and one to ensure the same numbers in each Kennedy classification.

The inclusion criteria for the study included participants who were 18 years or older, partially dentate with a stable occlusion, and controlled plaque formation with no prior prosthetic replacement of teeth.

We obtained ethical approval for the study from the Ethics Review Committee of the University of Ghana Medical School. Written and verbal informed consent was also received from the patients recruited into the study after explaining the nature of the study to them.

Clinical procedure

After recruitment, all the participants received oral prophylaxis and oral hygiene instructions. They were then randomly grouped into three groups by balloting: A, B, and C. Groups A and B had five subjects each, and C had six. For each patient, three sets of dentures with the different denture bases under study (i.e., acrylic, cobalt chromium, and iFlex) were fabricated. Preliminary impressions were made in irreversible hydrocolloids, and diagnostic casts were poured. The shade and the molds of the teeth to be used were then selected and checked with the patient. The diagnostic casts were surveyed, and designs for each denture were drawn. Mouth preparation including the preparation of rest seats and guide planes was carried out. Using chemical-cured acrylic resin, custom trays were constructed for each patient, and final impressions were made with regular-bodied silicone impression material. Master casts along with three duplicates were made. Three laboratory work authorizations were then written for each patient, one each for an acrylic resin denture,

iFlex, and a cobalt-chromium denture. After fabrication, the metal frameworks for the cobalt-chromium dentures and the final waxed RPDs were all tried and verified clinically. Once satisfactory, they were processed. The finished prosthesis once obtained from the laboratory was inserted and adjusted, and the occlusion was checked.

Three precalibrated dentists then evaluated the quality of the denture constructed and declared it acceptable before it was delivered. Objective quality evaluations of the dentures were carried out using the portion of the California Dental Association system designed for removable prostheses (9). All unacceptable dentures were then remade, and the process was repeated. Once the dentures were judged acceptable, the patients were taught how to insert and remove them, after which verbal and written post-denture delivery instructions were given.

Assessment of masticatory efficiency

After delivery of the dentures, each patient was asked to wear each denture while masticatory efficiency was assessed for each. This was carried out by asking the patients to chew 5.0 g of fresh raw carrots with 20 strokes on their preferred chewing side. They were then made to expectorate the comminuted carrot particles as thoroughly as possible. The recovered comminuted raw carrots were then strained through a mesh screen (5 mm × 1 mm), air-dried for 30 min, and weighed with an Axis AGN 50 series weighing scale. The volume of the carrot that remained on the sieve and that which passed through the sieve was assessed. Masticatory efficiency was defined as the volume of food that passed through the sieve divided by the total volume of comminuted carrot recovered expressed as a percentage (10).

Subjective assessment of masticatory function

After assessing masticatory efficiency, the patients were given one prosthesis to wear for a week at a time. The other two were then held onto, and one delivered and the other two were subsequently delivered on the second and third weeks when the previous one in use had been collected. Group A wore the dentures in the order: cobalt chromium, iFlex, and acrylic; Group B: acrylic, cobalt chromium, and iFlex; and Group C: iFlex, acrylic, and cobalt chromium. After 3 weeks, all three dentures were given to the patients to be worn interchangeably in the order they preferred for another 1 week.

After each week, patients were asked to complete a questionnaire, which sought to evaluate their satisfaction with the prostheses as related to chewing ability using a 100-mm VAS. After 4 weeks of having used all three dentures, another questionnaire was administered to assess which dentures the patients preferred when chewing.

The data were captured into a computer as double entries and later compared to correct errors in the database. It was then summarized using proportions and percentages for categorical variables and continuous variables were summarized by means and standard deviation. Kruskal–Wallis and one-way ANOVA were also used to establish the differences in masticatory efficiency between the three types of partial dentures. The tests were conducted at a 0.05 level of significance, and the data were analyzed using the IBM SPSS version 21 statistical software.

Results

Participant characteristics

Sixteen subjects with a mean age of 47.4 years and ranging between 24 and 73 years were recruited for the study. Six were males, and 10 were females. The number of missing teeth per arch ranged from 2 to 7 with a mean of 4 (**Table 1**).

Assessment of masticatory efficiency

Assessment of masticatory efficiency when the subjects were wearing the different dentures showed that the cobalt-chromium denture was the most efficient with mastication recording the highest mean score and the iFlex denture recording the lowest; however, there was no significant difference in masticatory efficiency between the three dentures (**Table 2**).

After each week of using the dentures, the patients subjectively rated their satisfaction with chewing while

TABLE 1 | Sociodemographic characteristics of participants.

Characteristic	Number (*n*)	Percentage %
Sex		
Male	6	37.5
Female	10	62.5
Age (years)		
<25	2	12.5
25–34	2	12.5
35–44	2	12.5
45–54	5	31.3
55–64	3	18.8
>64	2	12.5
Educational background		
Primary	5	31.3
Secondary	6	37.4
Tertiary	5	31.3
Marital status		
Single	5	31.2
Widowed	0	0
Married	11	68.8
Divorced/separated	0	0
Number of missing teeth per arch		
<4	3	18.8
4–6	11	68.7
>6	2	12.5

TABLE 2 | Masticatory efficiency of the subjects by type of denture (objective assessment).

Participant	Masticatory efficiency score %		
	Acrylic resin	Cobalt chromium	iFlex
1	54.5	38.9	47.1
2	25.0	41.7	24.4
3	57.6	8.5	4.0
4	2.0	6.0	6.1
5	35.1	28.2	56.3
6	6.3	6.7	19.0
7	5.3	11.3	11.1
8	28.2	62.2	45.5
9	4.2	17.8	4.2
10	55.6	60.3	52.3
11	23.6	37.8	29.4
12	44.8	61.8	41.2
13	35.5	38.9	34.7
14	33.8	29.2	31.4
15	16.6	22.7	19.9
16	22.3	31.1	19.2
Mean score	28.15 ± 18.58	31.44 ± 19.02	27.86 ± 17.2
***P*-value**		0.828	

wearing the different dentures. With this too, they rated the cobalt-chromium denture as the denture they were most satisfied with when chewing, with the least being the acrylic denture (Table 3). The subjective assessment of satisfaction with chewing also showed no significant difference between the different dentures.

While the overall satisfaction scores were similar for males and females, the females rated the acrylic denture higher and the males rated the iFlex denture higher (Table 4). There was, however, no statistical difference in satisfaction scores between the sexes. Also, while mandibular dentures and Kennedy class III dentures had higher satisfaction scores, they showed no significant differences.

After 4 weeks, the participants selected one of the dentures as their preferred choice overall and for chewing. While the iFlex denture was selected as the overall most satisfactory denture, the cobalt chromium was, however, selected as the most satisfactory denture for chewing (Table 5).

Discussion

This study assessed the subjective experience of masticatory function and masticatory efficiency in patients wearing acrylic resin, iFlex flexible, and cobalt-chromium RPDs. The cobalt-chromium denture recorded the highest masticatory efficiency score followed by the acrylic resin denture, with the iFlex denture having the least score. There was, however, no significant difference in the masticatory efficiency between the three dentures. This may be because the cobalt-chromium denture is tooth-borne for the Kennedy classes III and IV, and a combination of tooth and mucosa borne

TABLE 3 | Satisfaction (VAS scores) with chewing as judged by the participants (subjective assessment).

Denture	Mean VAS (cm)	Overall mean VAS	Standard deviation	95% Confidence interval	*P*-value
Acrylic	7.4	8.2	2.32	5.74–9.05	0.056
Cobalt chromium	9.3		0.95	8.62–9.97	
iFlex	7.8		1.75	6.54–9.05	

TABLE 4 | Satisfaction with chewing by sex, arch type, and Kennedy classification.

Characteristics	Satisfaction with chewing Mean VAS cm ± SD				*P*-value
	Acrylic	Cobalt chromium	iFlex	Pooled	
Sex					
Male	6.50 ± 2.38	9.50 ± 0.58	8.50 ± 1.29	8.17 ± 1.95	0.742
Female	8.00 ± 2.28	9.17 ± 1.17	7.33 ± 1.97	8.17 ± 1.92	
Arch					
Maxilla	6.66 ± 2.66	9.33 ± 0.52	7.67 ± 1.86	7.89 ± 2.11	0.811
Mandible	8.50 ± 1.29	9.25 ± 0.52	7.67 ± 1.86	8.58 ± 1.51	
Kennedy classification					
I	7.00 ± 0.02	7.00 ± 0.10	9.00 ± 0.71	7.67 ± 1.15	0.131
II	7.50 ± 2.12	9.5 ± 0.71	6.50 ± 0.07	7.83 ± 1.72	
III	8.25 ± 2.36	9.75 ± 0.50	8.25 ± 1.71	8.75 ± 1.71	
IV	6.33 ± 3.21	9.33 ± 0.58	7.67 ± 2.52	7.78 ± 2.44	

TABLE 5 | Post-treatment subject preference by arch.

Feature	Maxilla $n = 8$			Mandible $n = 8$			Total		
	Acrylic	Cobalt chromium	iFlex	Acrylic	Cobalt chromium	iFlex	Acrylic	Cobalt chromium	iFlex
Overall most satisfactory	3	1	4	3	2	3	6	3	7
Overall least satisfactory	4	4	0	4	4	0	8	8	0
Most satisfactory chewing	2	3	3	3	5	0	5	8	3
Least satisfactory chewing	4	3	1	5	3	0	9	6	1

for Kennedy classes I and II provides a more stable and rigid platform for mastication. The acrylic resin and iFlex dentures are, however, both mucosa borne, with the acrylic resin denture being more rigid than the iFlex denture, and will therefore provide more resistance for mastication making it preferred for chewing. Vozza et al. (6) in a study assessing the maximum biting forces with the different dentures also observed that patients wearing cobalt-chromium dentures recorded an increased maximum biting force compared with those wearing polymethylmethacrylate and Valplast RPDs. They attributed their finding to the lack of rests on acrylic and flexible dentures, resulting in the dentures sinking with mastication resulting in inflammation and pain around the abutment teeth, restricting the closure force. Notwithstanding this, Abel and Manly (11) in comparing masticatory efficiency with tooth-supported and free-end distal-extension partial dentures also observed no difference in masticatory efficiency. de Souza e Silva et al. (12) noted that the presence of at least 20 teeth is enough to ensure satisfaction with mastication and maintain adequate chewing ability. Thus masticatory efficiency may not have been compromised enough to see any differences in added effect between the three different dentures as the majority of the subjects possessed greater than 20 teeth.

Subjective assessment by the subjects also observed that the cobalt-chromium denture scored highest as the most satisfactory denture for chewing. However, with the subjective assessment, the acrylic denture and not the iFlex denture was scored the least. With the subjective assessment too, there was no significant difference in the mean VAS scores when they rated their satisfaction in chewing with the different dentures. One may argue that even if there were any differences in the masticatory efficiency between the three dentures, they may have compensated for the difference by increasing the number of strokes when chewing and therefore not seeing it as a problem affecting their satisfaction with chewing when using the denture. Also, it is possible that the subjects adapted their masticatory movements to the features of the different dentures. Johan (13) in comparing masticatory efficiency among individuals with their natural teeth, with complete maxillary and partial mandibular dentures, and with complete dentures, observed that those with dentures compensated for decreased masticatory efficiency by using more strokes when chewing. De Lucena et al. (14) reported no positive correlation between masticatory tests and patients' perceptions of their ability to chew. Using self-assessment is therefore not sufficient to evaluate masticatory performance as it lacks objectivity. An assessment of both variables, i.e., objective assessment of masticatory function, and patients' assessment of masticatory function of dentures may yield more information. Murakami et al. (15) in studying which factors contributed to this disparity observed that, though the number of remaining functional teeth individuals had was unrelated statistically to differences between objective and subjective assessment, the differences were related to mental and physical function. Boretti et al. (2) in a review of several epidemiological studies also reported that subjective measures of masticatory function were often overrated when compared with functional assessment. He concluded that it depended on a variety of subjective and personal factors that cannot be easily influenced by the oral healthcare practitioner.

Although studies have been carried out assessing masticatory function both subjectively and objectively after the fabrication of RPDs (3), this study is unique in comparing masticatory function objectively and subjectively while wearing three different types of dentures made from three different denture bases. The cobalt-chromium denture has been seen to be much superior to the other two dentures because it provides tooth support. And this study confirmed it by it showing relatively better function with mastication both objectively and subjectively though this difference was not significant. Long-term follow-up may, however, be needed to be carried out to explore if there will be any changes in masticatory efficiency with long-term use.

Conclusion

In this study, there was no significant difference observed in the masticatory efficiency assessment and in the subjective experience of masticatory performance between the three dentures, suggesting that mastication with three different prostheses was equally efficient. Each of the three different types of RPDs assessed may present its own unique advantages and disadvantages. Despite the fact that the iFlex flexible denture has an overall appeal,

where chewing is of great concern to prospective RPD patients, the cobalt-chromium denture may have a slightly better advantage.

This study had a few limitations that call for a cautious interpretation of its findings. The subjects had a relatively short time with the dentures: 1 week for each denture and another week where they had all three dentures before the evaluation was carried out. Long-term studies on satisfaction may also need to be carried out to see if they will yield the same results.

Author contributions

SH conceived and planned the study and took the lead in writing the manuscript. EN and OD supervised and guided the study, TN helped with the statistical planning and analysis. All authors discussed the results, provided the critical feedback, and helped to shape the research, analysis, and manuscript and contributed to the final version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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