EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 69, 2933:2942, OCTOBER, 2023
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
FIXED PROSTHODONTICS AND DENTAL MATERIALS
Submit Date : 19-07-2023 • Accept Date : 13-08-2023 • Available online: 15-10-2023 • DOI : 10.21608/EDJ.2023.224053.2643

ASSESSMENT OF ACOUSTIC SPEECH SIGNALS AND PATIENT SATISFACTION WITH TWO PARTIAL DENTURE FRAMEWORK MATERIALS IN MAXILLARY KENNEDY CLASS IV CASES. A RANDOMIZED CROSSOVER STUDY

Nancy Nader El-Sherbini *

ABSTRACT

Aim: This study aimed to measure the effect of two different framework materials on speech.

Materials and methods: Twenty participants with maxillary class IV arches (maxillary four anterior teeth missing) each patient received two prostheses alternating in a cross-over design. For both prostheses, CAD designed and printed resin patterns of the framework were made. For the Co-Cr metallic framework, the resin was then invested and cast conventionally. For the PEEK group, it was constructed by injection molded technique (for two press technique). Evaluation of speech was done on the same visit of prosthesis insertion, then patients were scheduled for one and three months follow-up visits for each prosthesis using a Computerized Speech Lab (CSL) (spectrogram). The Visual analog scale (VAS) was used to assess the level of patient satisfaction using a questionnaire three months after denture insertion.

Results: For speech evaluation: the PEEK group showed higher statistical significance mean duration for all sounds compared to Co-Cr group after three months $p \leq 0.05$. Also PEEK showed lower frequency levels for all sounds $p \leq 0.05$ except (n,l) $p > 0.05$. For patient satisfaction: PEEK RPD recorded significantly higher satisfaction scores group as regard the esthetic appearance, comfort and overall general satisfaction compared to the Co-Cr RPD group but there were insignificant differences ($P > 0.05$) between the two groups regarding retention, stability and masticatory function.

Conclusion: Co-Cr RPDs showed better speech qualities compared to PEEK RPDs. Patients with PEEK frameworks were more satisfied regarding RDPs appearance, comfort and overall satisfaction than patients with metallic Co-Cr frameworks.

KEYWORDS: PEEK RPD, Co-Cr RPD, digitally designed pattern, speech analysis, patient satisfaction.

* Associate Professor, Department of Prosthodontics, Faculty of Dentistry, Cairo University, Egypt

INTRODUCTION

Speech is an important part of human development and is the means by which persons can communicate with each other. The production of speech involves neural, muscular, mechanical, aerodynamic, acoustic and auditory elements. Restoration of missing anterior teeth with a dental prosthesis may be accompanied with initial disturbance.[1] Being a part of the oral structures, a prosthesis is critical for re-establishing the proper fluently running speech.[2]

Restoration of lost teeth and associated structures is important to improve appearance, reinforce masticatory efficiency, prevent unwanted movements of teeth (overeruption/drifting), and improve phonetics.[3]

Speech impairment significantly affects the quality of life of removable partial denture (RPD) wearers.[4] RPDs designed to cover a large area of the palate, especially the anterior palate, tend to disturb speech production.[5]Removable partial dentures (RPDs) are usually indicated in Kennedy class IV situations when the edentulous span is long in this case tooth and tissue support is required in the design. Also in cases with advanced ridge resorption, it is necessary to support the middle third of the face by a denture flange. In young patients with large pulp horns for whom preparing the teeth is contraindicated for a fixed prosthesis and when implant-supported restorations are contraindicated particularly in the old age group.[6-8]

Although cobalt-chromium is usually considered the best and most commonly used material for a denture framework, yet the esthetically unacceptable display of metal clasps, increased prosthesis weight, potential for metallic taste, oral galvanism, bio-film production and allergic reactions to metals have led to the introduction of many thermoplastic materials in clinical practice.[9-11]High performance polymers as frameworks are marketed to clinicians as e.g. Bio-HPP PEEK as an alternative to the metallic RPD. However, they showed the applicability of PEEK material in dentistry offering the patient a metal-free restoration with excellent mechanical properties. Also, the application of digital designing into the conventional RPD is expected to add to the accuracy, fit, comfort, speech fluency, and the overall qualities of the final restoration to decrease the chance of an all conventional treatment line.[12-14]

Spectrograms are considered a safe method to study the voice quality. It involves the proper choice of sounds that are of significance for the optimal examination of the phonetic spectral properties in the spectrogram. The acoustic signal changes of the sounds may be due to the artificial teeth not being aligned correctly or the denture base of the prostheses being too thick.[15]

Patient satisfaction is one of the most important relevant outcomes to be evaluated in clinical studies and many questionnaires are available for clinical application. The aim of patient satisfaction assessment is to determine the degree of patients' acceptance of a new prosthesis which is an important measure of the success of the treatment.[16]

So, This study aimed to detect the difference in the framework material used for fabrication of RPD on speech quality and patient satisfaction.

The study's null hypothesis was that both frameworks will have the same results regarding speech analysis and patient satisfaction.

MATERIALS AND METHODS

Patients' selection:

Patients were selected from the outpatient clinic, Prosthodontics Department, Faculty of Dentistry, Cairo University,

The study included twenty participants with maxillary class IV arches (maxillary four anterior teeth missing) opposing a fully dentate mandibular arch.

Inclusion criteria: The patients' age group ranged from 30 to 45 years. All patients had Angle's class I maxilla-mandible relationship, loss of

teeth was due to caries not periodontal disease to make sure no inflammatory mediators in bone or periodontal tissues.

Exclusion criteria: Patients with auditory defects, tongue-tie, poor neuromuscular control, or bruxer patients, as well as patients with crowding in the mandibular anterior teeth or unusual soft tissue undercuts in areas involved in the RPD design.

For both groups, the Exocad software designed resin pattern of the framework was constructed to take the advantage of an accurate free-hand printed resin pattern with accurately designed dimensions avoiding free-hand errors.

For the Co-Cr metallic framework, the resin was then invested and cast conventionally. For the PEEK group it was constructed by injection molded technique (***for two press technique***).

All patients were informed about the whole procedure and allowed to sign a written consent.

The patients were evaluated on the day of insertion, one month and three months after insertion.

Randomization was done for the sequence of which prosthesis the patient will start with.

Preoperative procedures:

Digital panoramic X–ray was done for each patient to ensure no impacted or septic foci that may affect the prognosis of the prosthesis after which periapical films were made for the proposed abutments using the parallel long cone technique to define the crown root ratio and the supporting alveolar bone.

Steps of RPD construction:

Preliminary impressions were made for both arches using irreversible hydrocolloid impression material (CA37; Cavex Holland BV, Haarlem, Netherlands) in a stock tray. Impressions were poured to obtain study casts on which acrylic custom trays were fabricated using auto-polymerizing acrylic resin (Acrostone, Cairo, Egypt). Primary surveying of the maxillary study models was done to ensure and locate the presence of desirable undercuts to select the suitable clasp assembly using a NEY surveyor. Mouth preparation was done. After which the final impression was made by medium body elastomeric impression material. The impression was then poured with extra hard dental stone (type IV, Elite Rock; Zhermack).

Digital process and CAD Design RPD Frameworks:

The master cast was then fixed on the scanner table and scanned using an extraoral 3D scanner (Zirkonzahn S600 ARTI Scanner, Italy) to obtain the STL file. The STL file was imported to the EXOCAD software (3Shape Dental System, version 2.9.9.3). Then, RPD design was digitally standardized for all frameworks. The design consisted of two cingulum rests on each canine and a double Akers clasp on the 2nd premolar and 1st molar and horseshoe maxillary major connector. The width and thickness of any part of every component were selected at these points depending on the material properties for optimal quality of the prostheses. The resin patterns of the frameworks were then printed by using a 3D printer. Each resin pattern was tried in the patient's mouth to make sure of the proper adaptation and verification of all components.

Casting the Co-Cr framework:

The resin patterns were conventionally sprued, invested then cast into Co-Cr frameworks. This was followed by try-in of the metallic frameworks intraorally, jaw relation registration, mounting and arrangement of the artificial teeth. Try-in of the waxed denture was done after which a putty index was made for the position of the anterior teeth so that for each patient the next prosthesis the teeth will be arranged in the same position as the previous denture to make sure of standardization of teeth position. Processing of acrylic resin was done conventionally.

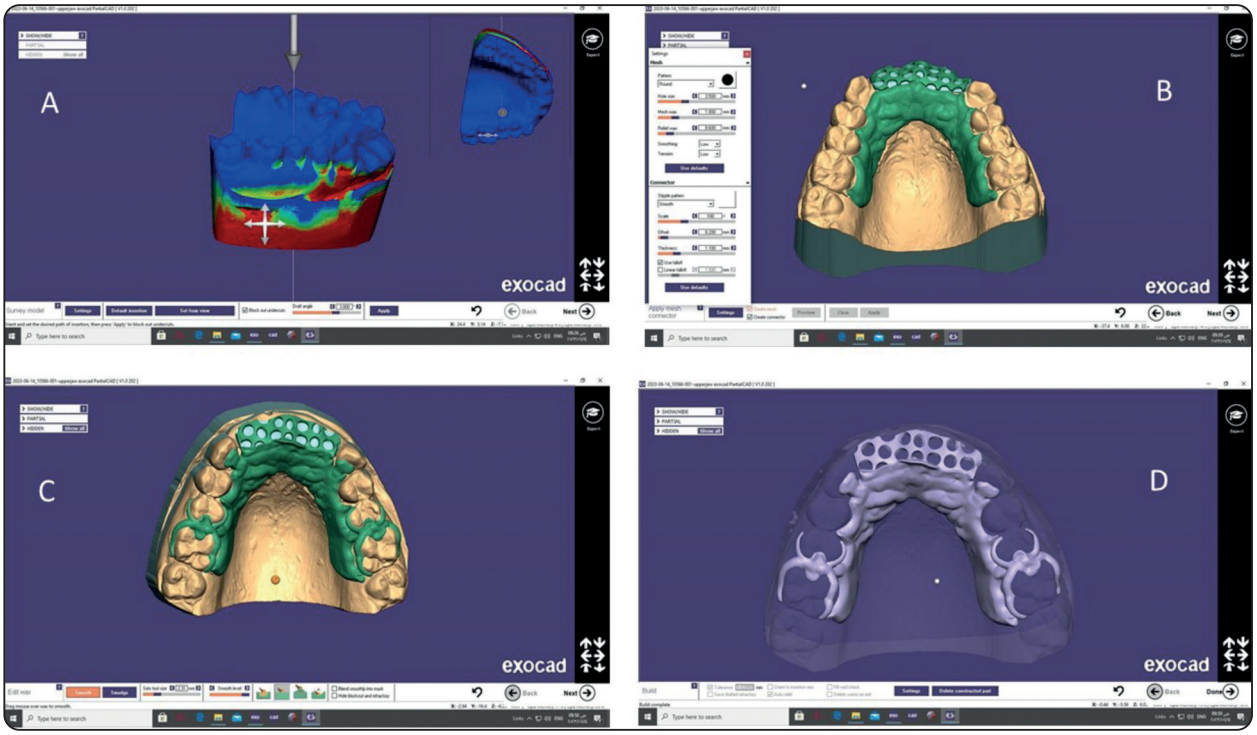

Fig. (1) A: Adjust the anteroposterior tilt and block out the undesirable undercuts. B: The outline of the design is marked. C: Finished design with the finish line.D: final framework design ready for printing the resin.

Fabrication of the PEEK framework

Investing of the resin pattern was done using *for* two press machine (*for* 2 press, bredent, Germany). Light polishing was done by Diagen Turbogrinder, green (6-8000rpm-Bredent-Seden-Germany-Batch number: REF 34000200) and Ceragum rubber polishing cylinder (6-8000rpm-Bredent-Seden-Germany-Batch number: REF PWKG00650) with light pressure then the final PEEK framework was fitted on the stone cast.

The PEEK framework was then tried in the patient's mouth after which jaw relation registration, mounting, and arrangement of the artificial teeth was done the putty index was used to arrange the incisors teeth. Try-in of the waxed denture and processing of acrylic resin was done conventionally.

Outcomes Measurements

Speech analysis

Evaluation of speech was done using Computerized Speech Lab (CSL) (spectrogram) (CSL Kay Elemetrics Model 4300, USA) in the Phoniatric Unit, Faculty of Medicine, Cairo University. The evaluation was carried out on the same visit of prosthesis insertion, then patients were scheduled for one and three months follow-up visits.

Before starting sound analysis: The patient was asked to identify him/herself in terms of name, occupation, and address, also the patient was asked to count from 1-20 to allow for engagement in a short conversation before starting the professional assessment.

The patient was asked to sit upright in a comfortable position to allow for normal, steady, and uninterrupted speech flow for accurate recording of the sound signals. For each sound, both duration of the sound production (in millisec.) and the spectral analysis of the obtained signal (energy) in frequency (HZ) were examined. The microphone (Sony Fv-120, made in Londerzeel Belgium) was fixed at a distance of 10 cm from the patient's mouth.

Two parameters were evaluated: Sound duration and frequency.

Lingualveolar sounds that are usually affected by the thickness of the major connector covering the anterior part of the maxilla related to the area of articulation were evaluated and they included: Stops /t/, /d/, Fricatives (/sh/,/s/), laterals/l/) and Nasal(/n/).The sounds were included in words to allow the patient to easily pronounce those sounds. **(Table 1)**

TABLE (1) Sounds tested in the study.

Sound	Word
Nasal (n)	نار
Stops (t)	توكه
Stops (d)	دلو
Fricative(sh)	شوكة
Fricative(s)	صورة
laterals(l)	لون

Patient satisfaction:

Visual analogue scale (VAS) was used to assess the level of patient satisfaction using a questionnaire. Satisfaction after three months follow-up period was tested regarding comfort, esthetics, stability, retention, speech easiness, masticatory function and overall satisfaction. Each patient was asked to rate each item from 0 (extremely unsatisfied) to 100 (extremely satisfied). The mean of the answers (length of the lines from zero to the 100 marks in mm) for each item was then used for statistical analysis.

Statistical analysis

Samples were calculated with spectrographic analysis. Repeated measures analysis of variance (ANOVA) was used to compare means. Bonferroni's test for pair-wise comparisons was used to determine a significant difference between means when ANOVA was significant. The significance level was all set at ***p≤0.05.***

For comparing **patient satisfaction** between the two groups, Mann-Whiteny test was utilized.

RESULTS

Speech results:

I) For the mean duration (milisec.) of sound production:

Effect of time within each group:

1. ***Within Co-Cr group:***

Within this group for all sounds under investigation, there was a decrease in the mean duration of sound production through the three follow-up periods, yet there was a statistically significant decrease between 1 month and at insertion and three months versus insertion P<0.0001

Yet there was no statistical significance in the mean duration between 1 month and 3 months ***p > 0.05***

2. ***Within the PEEK group:***

Within this group all sounds under investigation there was a decrease in the mean duration of sound production through the three follow-up periods, yet there was a statistically significant decrease between 1 month and at insertion and 3 months versus insertion P<0.0001. Yet there was no statistical significance in the mean duration between 1 month and 3 months ***p > 0.05***

Effect of framework material (Co-Cr) and PEEK on the mean duration (milisec.) of sound production:

At insertion, there was a statistical significance difference in the mean duration of all sounds ***p≤0.05.***

At 1 month the difference in mean duration between both groups was significant in (t, sh,s,l) ***p≤0.05.*** While for (n,d) sounds although the PEEK group showed higher mean duration compared to the Co-Ct group yet this difference was not statistically significant ***p > 0.05***

TABLE (2) The mean durations in millisecond of sound production for both (Co-Cr, PEEK)

Group	Follow up period	Co-Cr group		PEEK		*P- value*
Sound		**Mean**	**SD**	**Mean**	**SD**	
Nasals (n)	**At insertion**	5.81	0.56	6.74	0.42	P=0.0005*
	At 1 month	4.93	0.48	5.24	0.31	P=0.103
	At3months	4.65	0.81	5.24	0.78	P=0.114
	P- value	P<0.0001*		P<0.0001*		
Stops (t)	**At insertion**	4.79	0.42	5.92	0.71	P<0.0004*
	At 1 month	3.66	0.57	4.64	0.55	P=0.001*
	At 3 months	3.48	0.64	4.33	0.59	*P=0.006
	P -value	P<0.0001*		P<0.0001*		
Stops (d)	**At insertion**	6.22	0.39	6.94	0.67	P=0.008*
	At 1 month	4.85	0.71	4.83	0.54	P=0.944
	At 3 months	4.47	0.52	5.46	0.61	P=0.001*
	P -value	P<0.0001*		P<0.0001*		
Fricative(sh)	**At insertion**	7.12	0.65	7.97	0.67	P<0.01*
	At 1 month	6.03	0.44	7.24	0.41	P<0.0001*
	At 3 months	5.66	0.39	6.75	0.43	P<0.00018
	P -value	P<0.0001*		P<0.0001*		
Fricative(s)	**At insertion**	6.34	0.57	6.88	0.23	P=0.012*
	At 1 month	4.86	0.34	5.92	0.54	P=0.0001*
	At 3 months	4.54	0.51	5.65	0.42	P<0.0001*
	P- value	P<0.0001*		P<0.0001*		
Laterals (l)	**At insertion**	5.97	0.44	8.21	0.65	P<0.0001*
	At 1 month	4.73	0.32	7.45	0.76	P<0.0001*
	At 3 months	4.47	0.28	5.97	0.35	P<0.0001*
	P -value	P<0.0001*		P<0.0001*		

At three months the difference in mean duration between both groups was of statistical significance for all sounds ***p≤0.05*** except for (n) sound ***p > 0.05***

II) Changes in frequency (Hz):

a. Effect of time within each group:

1. Co-Cr group:

Although all sounds showed an increase in their frequencies through the three follow-up periods yet this increase was statistically significant at insertion and one month, at insertion and 3 months ***p≤0.05*** yet no significance in this increase appeared between 1month and three months. ***p > 0.05.***

2. PEEK group:

Although all sounds showed an increase in their frequencies through the three follow-up periods yet this increase was statistically significant at insertion and one month, at insertion and three months ***p≤0.05*** yet no significant in this increase appeared between one month and three months. ***p > 0.05.***

c. Effect of framework material (Co-Cr and PEEK)

Co-Cr showed higher frequency levels compared to PEEK

At insertion, Co-Cr showed higher frequency levels compared to PEEK yet this difference was

statistically significant in (t, sh) sounds ***p≤0.05,*** and of no significance in (n,d,s,l) ***p > 0.05.***

At 1 month, the difference in frequency values between both groups was statistically significant in all sounds ***p≤0.05*** except for (n,l) ***p > 0.05.***

At 3 months, the difference in frequency values between both groups was statistically significant for (t,sh,s) ***p≤0.05.*** While for (n,d,l) sounds there was no statistically significant difference in values of frequency of both groups ***p > 0.05***

Patient satisfaction parameters: (TABLE 4)

VAS scores for speech easiness were significantly higher for the **Co-Cr RPD** group as compared to the **PEEK RPD** group. However, significantly higher satisfaction scores were recorded for the **PEEK RPD** group as regards the esthetic appearance, comfort, and overall general satisfaction as compared to the **Co-Cr RPD** group **P<0.05. There were insignificant differences** (P>0.05) **between the two groups as regard** retention, stability, and masticatory function.

TABLE (3) The mean maximum energy (frequency Hz) of sound production for both (Co-Cr,PEEK)

Group	Follow up period	Co-Cr group		PEEK		P- value
Sound		**Mean**	**SD**	**Mean**	**SD**	
N sound	**At insertion**	945.2	89.3	932.8	76.4	0.742
	At 1 month	1102.4	108.7	1089.5	100.2	0.785
	At3months	1220.6	154.7	1199.6	154.6	0.764
	P- value	P<0.0001*		P<0.0001*		
Stops (t)	**At insertion**	889.5	78.3	680.7	88.2	P<0.0001*
	At 1 month	1010	75.2	754.4	90.9	P<0.0001*
	At 3 months	1086.1	39.4	839	56.4	P<0.0001*
	P- value	P<0.0001*		P<0.0001*		
Stops (d)	**At insertion**	978.2	98.2	990.6	87.4	0.768
	At 1 month	1096.5	78.8	1123.3	55.2	P<0.0001*
	At 3 months	1236.6	66.1	1223.4	79.5	0.691
	P- value	P<0.0001*		P<0.0001*		
Fricative(sh)	**At insertion**	1690.5	44.5	1603.4	101.3	0.02*
	At1 month	1804.2	65.2	1721.9	58.2	0.008*
	At 3 months	1915.7	29.7	1800.2	36.6	P<0.0001
	P- value	P<0.0001*		P<0.0001*		
Fricative(s)	**At insertion**	1632.5	65.4	1598.8	69.2	0.277
	At 1 month	1776.6	78.2	1647.3	109.2	0.007*
	At 3 months	1813.3	15.4	1732	24.2	P<0.0001
	P- value	P<0.0001*		P<0.0001*		
Laterals (l)	**At insertion**	1554.2	79.7	1520.3	88.4	0.379
	At 1 month	1669.5	48.5	1654.4	55.2	0.524
	At 3 months	1720.4	38.8	1712.3	27.8	0.598
	P- value	P<0.0001*		P<0.0001*		

Significance at p≤0.05

TABLE (4) Comparison of VAS scores (mm) for both RPD groups.

	PEEK RPD		Co-Cr RPD		P –value
	Mean	SD	Mean	SD	
RPD Retention	93	5.6	96	4.8	0.21
RPD stability	90	7.4	87	8.7	0.42
RDP appearance	92	5.3	72	8.7	<0.0001
Comfort	96	6.8	81	4.5	<0.0001
Masticatory function	88	5.6	86	5.8	0.44
Speech easiness	71	6.8	92	7.4	<0.0001
Overall satisfaction	94	4.3	82	5.5	<0.0001

DISCUSSION

Loss of maxillary anterior teeth is accompanied by disturbance in the appearance as well as the speech function. [17] Therefore, one of the most important concerns when restoring and rehabilitating these patients is to take into consideration these issues. Material selection for constructing RPDs should be based on clinical examination, patient demands, as well as scientific evidence. Partial denture insertion will usually be accompanied by some disturbance in the production of certain sounds. This can be due to the anterior teeth position however this was standardized through the index used for their arrangement, or to the inherent design specifications in the framework. [18,19]

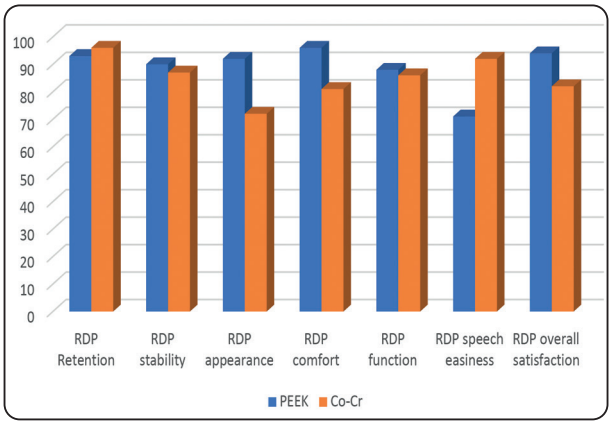

Fig. (2) Bar chart showing the results of VAS scores for both groups

Nasals(n) production depends on the blocking of oral air flow and allowing it to circulate through the nasal cavity. T and D are studied as a pair because both are stop consonants in which the tongue stops the flow of air at the front of the oral cavity the main difference is in the amount of air expelled which is more in D than T. [15] (S,T,D, N,L) theses sounds depends on the thickness of the denture, the anteroposterior position of teeth, vertical dimension of occlusion and the width of the dental arch in addition to the relation between upper and lower anterior teeth for the (S)sound. [20]

In both groups (**Co-Cr and PEEK**) the mean duration of sound production at the time of denture insertion was longer compared to the duration at one month of insertion while no significant change occurred after 3 months. Speech is greatly affected by the inclination of maxillary anterior teeth as well as the thickness of the anterior palatal surface of the denture. This was found to be a normal finding since the patients were not yet accommodated to their new dentures immediately after insertion. By time, patients get more and more adapted to their new dentures which is consequently reflected on their speaking ability and quality. This was proven in the follow up visits in which there was obvious improvement in denture accommodation manifested by the shorter mean duration of sound production. [16,20]

PEEK group showed overall higher mean duration of sound production compared to the **Co-Cr group** this could be attributed to the difference in the inherited material properties that required thicker components to compensate for the difference in the material hardness and so this was reflected on the sound duration. Moreover, the thickness of the PEEK in the palatal area led to the early tongue contact which also might explain the higher duration of sound production in case of the **PEEK group**. [22]

Regarding the sound energy (frequency) results the **Co-Cr group** showed higher frequencies compared to **the PEEK group.** Yet not all sounds showed statistical significance. High-frequency sounds are those reaching 2,000 Hz and beyond. And so, the results obtained indicated that both prostheses are clinically accepted regarding the impact on sound quality. The thickness of the denture base has a direct effect on the size of the oral cavity specially in the vertical direction as it becomes shorter so the presence of more vertical space in the **Co-Cr group** making more freedom and comfort for the tongue articulating position nearest to the pre-prosthesis position with the palatal tissue. [23]

Regarding patient satisfaction with each prosthesis; patient comfort was higher in the **PEEK group** than Co-Cr **group** and this could be attributed to the weight of the prosthesis which usually has a major influence on the patient's comfort. [24,25] PEEK has a low specific weight thus allowing the construction of light weighed prostheses with good functionality offering high patient satisfaction and comfort through function. [22] (Zoidis et. al., 2016) reported that the PEEK RDP weighed 27.5% less than its Co-Cr predecessor.

Aesthetic satisfaction scores were higher with the PEEK group than the **Co-Cr** group. This was an expected result due to the unaesthetically pleasing metal display of the clasps in the Co-Cr group. Because of the increased prosthesis weight, the potential for metallic taste, and possible susceptibility to allergic reactions to metals. [10,13] Several esthetically acceptable thermoplastic materials were introduced in clinical practice. Due to its white color and high strength, PEEK permits RPD fabrication with metal-free esthetic clasps.[26,27]

Retention, stability and masticatory ability there was no significance between both groups and this was attributed to the properly designed i.e. (The patterns were also digitally fabricated for the both groups) and constructed prostheses whatever the material of the framework construction in terms of engagement of proper undercuts and the selection of good quality posterior teeth.

Regarding the patient overall and general satisfaction, satisfaction scores recorded for the PEEK RPD patients were significantly higher than those recorded for Co-Cr patients. This is in agreement with (Mohamed & Rasha, 2019) who stated that **PEEK** frameworks allowed the patients to be more satisfied with their removable prosthesis more than conventional **Co-Cr** RPD, which will help to rehabilitate more partially edentulous patients with high appreciation and minimum complaints. [28,29]

Also, this suggests that the appearance of patients with missing anterior teeth plays a more influential role in their satisfaction with their prosthesis than their ability to speak (speech quality) with their prosthesis.

CONCLUSION

- **Co-Cr** RPDs showed better speech qualities compared to **PEEK** RPDs.
- Patients with **PEEK** frameworks were more satisfied regarding RPDs appearance, comfort, and overall satisfaction than patients with metallic **Co-Cr** frameworks.

REFERENCES

1. Özbeki M, Tulunoglu Í, Özkan S, Öktemer M. Evaluation of articulation of Turkish phonemes after removable partial denture application. Braz Dent J 2003; 14:125-131.
2. Godbole S, Phakhan AJ, Kale S, Dahane T. Prosthodontic considerations of speech in complete. J Dent Med Sci 2016; 15:41-44.
3. Rodrigues LC, Pegoraro LF, Brasolotto AG, Berretin-Felix G, Genaro KF. Speech in different oral prosthetic rehabilitation modalities for elderly individuals. Pro Fono 2010; 22:151-170.
4. Sharma A. and Tabassum A.: Evaluation of patient satisfaction for retention, masticatory efficacy, aesthetics and comfort for removable partial denture: A retrospective study. Int J.Appl Dent Sci. 2018; 4: 91 -93.
5. De Kok IJ, Cooper LF, Guckes AD, McGraw K, Wright RF, Barrero CJ. Factors influencing removable partial denture patient-reported outcomes of quality of life and satisfaction: a systematic review. J Prosthodont. 2017; 26: 5-18.

6. Hörschgen J, Wisser W, Berger R, Lotzmann U. [The influence of major connectors of partial dentures of phonation: an instrumental analysis of speech]. Folia Phoniatr Logop. 2004; 56: 144-156.

7. Campbell LD. Subjective reactions to major connector designs for removable partial dentures. J Prosthet Dent. 1977; 37: 507-516

8. Wada J, Hideshima M, Inukai S, Ando T, Igarashi Y, Matsuura H. Influence of the major connector in a maxillary denture on phonetic function. J Prosthodont Res. 2011; 55: 234-242.

9. Wöstmann B, Budtz-Jørgensen E, Jepson N, Mushimoto E, Palmqvist S, Sofou A, Owall B. Indications for removable partial dentures: A literature review. Int J Prosthodont 2005; 18:139-145.

10. Wiesli M. G. and Ozcan M.: High-performance polymers and their potential application as medical and oral implant materials: a review. Implant Dent. 2015; 24: 448-457.

11. Behr M, Zeman F, and Passauer T.: Clinical performance of cast clasp-retained removable partial dentures: A retrospective study. Int J Prosthodont. 2012; 25: 138-144.

12. Schwitalla A D, Spintig T, Kallage I, et al.: Flexural behavior of PEEK materials for dental application. Dental Mat. 2015; 31: 1377-1384.

13. Koyama S, Sasaki K, Yokoyama M, Sasaki T, Hanawa S. Evaluation of factors affecting the continuing use and patient satisfaction with removable partial dentures over 5 years. J. Prosthodont. Res. 2010; 54: 97-101.

14. Campbell SD, Cooper L, Craddock H, Hyde TP, Nattress B, Pavitt SH, Seymour D. Remov- able partial dentures: The clinical need for innovation. J Prosthet Dent. 2017; 118: 273-280.

15. Jain CD et al. Phonetics in Dentistry. Int J Dent Med Res 2014;1:31-37.

16. Balu K. Speech in prosthodontics, type of literature: commentary. JIADS 2011; 28:79-81.

17. StojcevićI, Carek A, BukovićD, Hedjever M. Influence of the partial denture on the articulation of dental and postalveolar sounds. Coll Antropol 2004;28:799-807

18. Zoidis P, Papathanasiou I, and Polyzois G.: The Use of a modified poly ether ether ketone (PEEK) as an alternative framework material for removable dental prostheses. A clinical report. J Prosthet Dent. 2016; 25: 580-584.

19. Ando T, Hideshima M, Inukai S, Igarashi Y, Matsuura H. Analysis of the relationship between palatal contour and the phonetic function in complete denture wearers using a speech recognition system. Prosthodont Res Pract 2006; 5:231-237.

20. Sadek SA. Comparative study clarifying the usage of PEEK as suitable material to be used as partial denture attachment and framework. Open Access Maced. J. Med. Sci. 2019;7:1193.

21. Cosme DC, Baldisserotto SM, Fernandes ED, Rivaldo EG, Rosing CK, Shinkai RS. Func- tional evaluation of oral rehabilitation with removable partial dentures after five years. J. Appl. Oral Sci. 2006; 14: 111-116.

22. Skirbutis G, Dzingutė A, Masiliūnaitė V, Šulcaitė G, Žilinskas J. A review of PEEK polymer's properties and its use in prosthodontics. Stomatologija. 2017; 19:19-23.

23. Mohamed SE, Rasha HG. Digital PEEK framework and patient satisfaction compared to conventional metal framework in removable partial dentures. A clinical trial. Egypt Dent J. 2019; 65:3787-3794.

24. Hakim M, Badr AMI. Evaluation of biting force for three different partial denture modalities in bilateral distal extension cases (crossover study). Egypt Dent J .2020; 66:1155-62.

25. Godara A, Raabe D, Green S. The influence of sterilisation processes on the micromechanical properties of carbon fiber- reinforced PEEK composite for bone implant applications. Acta Biomater. 2007; 3:209-20.

26. Cosme DC, Baldisserotto SM, Fernandes ED, Rivaldo EG, Rosing CK, Shinkai RS. Func- tional evaluation of oral rehabilitation with removable partial dentures after five years. J. Appl. Oral Sci. 2006; 14: 111-116.

27. Skirbutis G, Dzingutė A, Masiliūnaitė V, Šulcaitė G, Žilinskas J. A review of PEEK polymer's properties and its use in prosthodontics. Stomatologija. 2017; 19:19-23.

28. Mohamed SE, Rasha HG. Digital PEEK framework and patient satisfaction compared to conventional metal framework in removable partial dentures. A clinical trial. Egypt Dent J. 2019; 65:3787-3794.

29. Hakim M, Badr AMI. Evaluation of biting force for three different partial denture modalities in bilateral distal extension cases (crossover study). Egypt Dent J .2020; 66:1155-62.