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RADIOGRAPHIC ESTIMATION FOR THE EFFECT OF USING KARADENT VERSUS COBALT CHROMIUM FRAMEWORK ON THE SUPPORTING STRUCTURES IN BILATERAL DISTALLY EXTENDED PARTIAL DENTURE CASES

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KEYWORDS

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ABSTRACT

Introduction: Dental health is of great concern to many patients and long-span edentulous spaces are difficult to be replaced with fixed prostheses, so removable partial dentures are still required. **Aim:** The purpose of this research was to compare between the effect of distal extension karadent and cobalt chromium (Co-Cr) removable partial denture frameworks on the supporting structures. **Methods:** Twelve male patients with bilateral mandibular distal extension ridge (last tooth is the 2nd premolar) opposing maxillary full set of dentitions were selected. According to the frameworks material used the patients were divided equally into two groups: The control group received a mandibular removable partial denture (RPD) made of cobalt chromium, while the test group received a mandibular RPD made of the thermoplastic semi-rigid microcrystalline polymer material (karadent). The data was recorded and statistically analyzed. **Results:** The results of this study showed that there were reduction in the alveolar bone width and height in both karadent and metal frameworks, but is higher in karadent. The differences between the two groups were statistically non-significant at ($p \leq 0.05$). **Conclusion:** Based on the limitations of this study, it could be concluded that the karadent frameworks recommended in distal extension RPD cases seeking for esthetics, but it has an adverse effect on the supporting bone in Kennedy Class I partially edentulous patients than cobalt chromium RPD.

INTRODUCTION

Partial edentulism is a growing issue resulting in multiple problems that adversely affects mastication, speech, esthetics, overeruption, drifting, loss of space, unfavorable distribution of occlusal loads, tempero-mandibular disorders occlusal interferences and periodontal breakdown, all results in difficulty to achieve an adequate restoration in a partially edentulous patient. The degree of impact on appearance depends on both the site and number of missing teeth [1,2].

Many treatment modalities are available for replacing missing teeth; fixed partial dentures, dental implants, or removable partial dentures (RPD). Each modality has its own advantages and disadvantages [3].

Fixed bridges tend to be limited to short spans, and patients with acceptable abutments and suitable occlusal schemes. Conventional bridgework requires extensive preparation of abutment teeth and evidence suggests that 29.2% of these teeth will lose vitality after ten years. Implant-supported fixed partial dentures are the ideal treatment option for it, but bone loss in mandibular posterior region could require bone graft and mandibular nerve lateralization procedures for implant placement, causing high surgical risk and cost. So, removable partial dentures are still required [4].

Changes in patient's awareness have been apparent in all aspects of dentistry, especially aesthetics. In removable partial denture fabrication, unsightly metal framework have always been a cosmetic problem with traditional Co-Cr [5].

Introduction of thermoplastic resin materials such as nylon, acetal resins was a trial to improve esthetics and solve the problem of allergy. A non-metal, esthetic clasp denture produces a metal-free smile to the patient, comfortable to wear without causing any metal allergy and therefore it is superior to conventional clasp dentures [6].

More recently, the thermoplastic monomer free semi-rigid microcrystalline polymer (karadent) is introduced to the market in 2016. Karadent became a good alternative framework material for removable denture construction [7].

The bilateral distal extension base RPD has been associated with problems concerning support, retention, and stability. These problems are due to the absence of posterior abutments. Since, the difference in displacement between the mucosa and the periodontal ligament of last standing abutment was estimated to be up to 25 times. Consequently, forces applied to the distal extension base removable partial denture it is extremely damaging to the abutment teeth and must be controlled. The authors suggested that the most suitable treatment is by a removable partial denture with stress breaking action [8].

Retentive clasp arms should not unduly stress abutment teeth or be permanently distorted under service. Previous studies indicated that RPD clasps made of more elastic materials demonstrated a higher resistance to retention loss. Due to the low modulus of elasticity, karadent has superior flexibility compared to the conventional Co-Cr alloys [9].

The thermoplastic monomer free semi-rigid microcrystalline polymer (karadent by TCS, INC, USA) is introduced to overcome allergic reactions. Karadent Specifically formulated for full dentures, semi-rigid partials, clear clasps and frameworks. It combines the unbreakable strength of nylon with the simplicity of acrylic to create a comfortable, color stable, excellent-fitting appliance, strong and durable, repairable, relinable/rebasable with acrylics. Karadent is available in two shades pink and transparent, better esthetics are provided compared to conventional metal framework display. Therefore, the use of esthetic clasps in removable partial dentures can bring a metal-free smile to the patient [10].

The amount of bone loss in distally extended RPD cases is often used as a critical determinant to evaluate the durability of the prosthesis. Evaluation of the changes in the supporting structures of distal extension removable partial dentures radiographically is done by using the cone-beam computed tomography (CBCT) as it seems to be one of the most advanced and promising resources in this field [11].

So this research was done to radiographically evaluate the changes caused by karadent versus

Co-Cr frameworks in the supporting structures in distally extended partial denture cases.

Null hypothesis

The null hypothesis was that there would be no significant differences between karadent and Co-Cr frameworks on the supporting structures in distally extended partial denture cases.

Ethical Approval

Approval of the Research Ethical Committee of the Faculty of Dentistry, Suez Canal University (100/2018) was obtained before starting the study. Written informed consent of all the participants was obtained. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

MATERIALS AND METHODS

Sample Size calculation

Sample size calculation was performed using G*power version 3.1.9.2 (University Kiel, Germany).

The effect size was 1.6 using an alpha (α) level of 0.05 and a Beta (β) level of 0.05, i.e.; power = 95%; the estimated minimum sample size (n) was a total of 12 samples.

Twelve male patients with bilateral mandibular distal extension ridge (last tooth is the 2nd premolar) opposing maxillary full set of dentition, with age ranging between 35-60 years were selected for this study from those attended to the prosthodontic department, Faculty of Dentistry, Suez Canal University. All patients signed an informed consent after detailed discussion of the procedures and follow up visits.

The patients were selected according to the following inclusion criteria;

- Patients with mandibular Kennedy class I arches, with remaining lower right and left 2nd premolars, opposing maxillary full set of dentition.
- They have good oral hygiene
- The remaining teeth are free of periodontal diseases and having adequate bony support with no mobility.
- Edentulous residual ridges have normal morphology with minimal undercuts and without sharp edges, tori or tumors, covered with healthy firm mucosa, free of any signs of inflammation or flabby tissues.
- Patients with an angle class I maxillo-mandibular relationship with adequate interarch space.
- Last tooth extraction performed at least six months before commencing the treatment.

Exclusion criteria

- Patients with para-functional habits (bruxism and clenching) and heavy smokers.
- Patients with any septic foci or impacted teeth as verified by panoramic radiograph.
- Patients with tilted or rotated abutments, and soft tissue undercuts involved in the design were excluded.

Patients grouping and Preparation

Patients were randomly and equally with the aid of a randomization website and According to the frameworks material used the patients into two groups:

Group 1: received a mandibular removable partial denture (RPD) framework made of cobalt chromium.

Group 2**:** received a mandibular RPD framework made of the thermoplastic semi-rigid microcrystalline polymer material (karadent).

RPD Design

Designed according to the default RPD design of a class I mandibular RPD with a strategy of stress-releasing design as follow:

- The retention was provided by RPI clasp assemblies on mandibular second premolars.
- The reciprocation was provided by vertical minor connectors on the lingual surface of the abutments connected with mesio-occlusal rest located on mandibular second premolars which provides support.
- Major connector in form of lingual plate was used, which is extended from right to left mandibular second premolar teeth.
- Denture base designed to provide strength and carry prosthetic teeth.
- Cingulum rests act as indirect retainer on mandibular canines.

Abutments preparation

Abutment teeth were prepared for both groups as follows: proximal guiding planes of 1.5 mm occluso-gingival height on mandibular second premolars. Mesial saucer shaped occlusal rests were prepared in mandibular second premolars. Lingual rest seat were prepared on each canine as indirect retainers.

After mouth preparations final impressions were taken by a special acrylic resin tray (Self cured acrylic resin, Acrostone) using one stage selected pressure impression technique by applying softened modeling compound (Green stick compound, Kerr, Kerr U.K. limited, Netherlands) in the part of the tray opposing the residual edentulous ridge till obtaining perfect molded and optimally extended borders. The tissue surface of the compound was relieved except for the stress bearing areas .The impression was completed by overall rubber base impression (Orsnwash L zetal plus impression material, zermack SpA, Italy) applying finger pressure on the residual ridge [(12)].

Fabrication of cobalt chromium removable partial framework

After poring the final impressions, master casts were obtained, surveyed, modified and duplicated into refractory casts made with phosphate bonded investment material (Wirovest, Bego, Bremen, Germany) for fabrication of cobalt-chromium (Co-Cr) removable partial denture frameworks.

The phosphate-bonded investment material was poured into the mold. The refractory material was set for 1 hour. The casts were carefully removed from the molds and dried in an oven at 93°C (200 F) for 45 minutes. The wax pattern were fabricated using preformed casting wax sheets then were sprue, invested, and then left to bench sets for 2 hours. After setting it was placed in a thermostatically controlled furnace at room temperature then gradually raised to 300°C in 1 hour, then to 975°C in another hour. The temperature was maintained at 975°C for 30 minutes. An Electromatic centrifugal induction casting machine (How Medica, Inc., Chicago, Ill.) was used for casting. The cobalt-chromium alloy (Wironit, Bego) was casted in 1200°C. The sprues were cut-off and the castings were sandblasted to remove the residual investment material still adhering to the casting. Any metal nodules were removed with stones **(Figure 1 a-c)**.

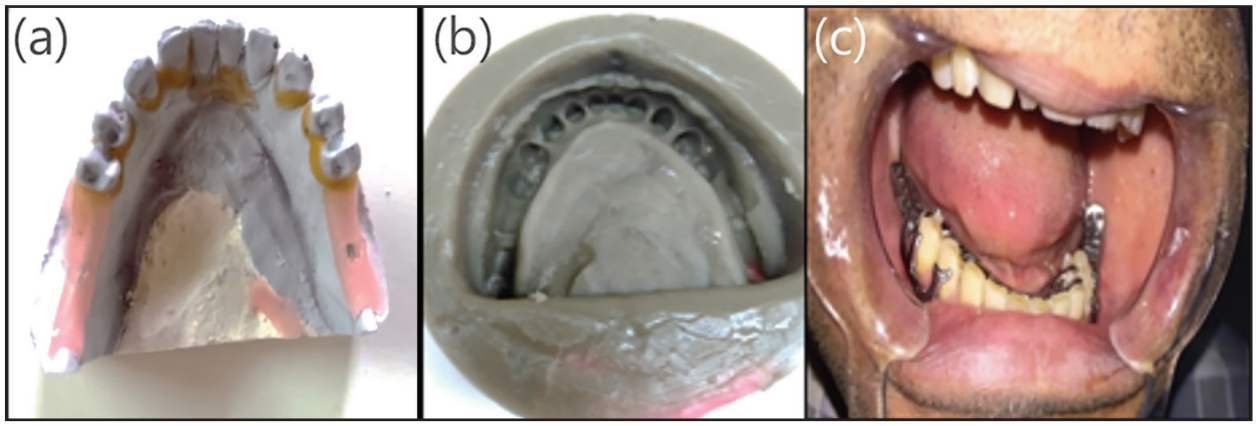

Fig. (1) Fabrication of cobalt chromium removable partial framework; (a) master cast with block out and relief; (b) duplicating the master cast; (c) metal try-in.

Jaw relation was registered after evaluation of the framework fitness. Selection and setting up of the teeth were done followed by try in and processing the dentures with heat cured acrylic resin

Fabrication of karadent removable partial framework

After poring the final impressions, master casts were obtained. Occlusion blocks were fabricated on the master cast. Jaw relation was registered, mounted on semi-adjustable articulator (Hanau Modular Articulator System; Waterpik Technologies, Inc.), and semi-anatomical teeth was set followed by the try in step to verify all the framework components and determine any needed corrections that would be done.

The wax patterns were fabricated using preformed wax sheets on the casts then the wax patterns were sprued. Investing the spurred wax patterns of the framework have been done in a vaselinezed aluminum flask. The flask was immersed into warm water of a thermostatic container after setting of the gypsum. When the wax was boiled and washed out and the mold was created, injection of Karadent (Karadent by TCS Dental Inc. USA) was carried out with the apparatus called Thermopress 400 injecting unit (BREDENT Themopress 400. bredent.co.uk), set display at 310-320°C for 14-16 min 150 – 165 PSI (melting time and temperature depends on furnace type and calibration). The cartridge of injecting material was introduced into one of the two heating cylinders after a Vaseline base lubricant has been applied at its closed end. The cartridge membrane is pointed to the flask chamber. After processing finishing and polishing was performed utilizing soft brushes and flourishing paste to obtain karadent RPD **(Figure 2 a-d)**.

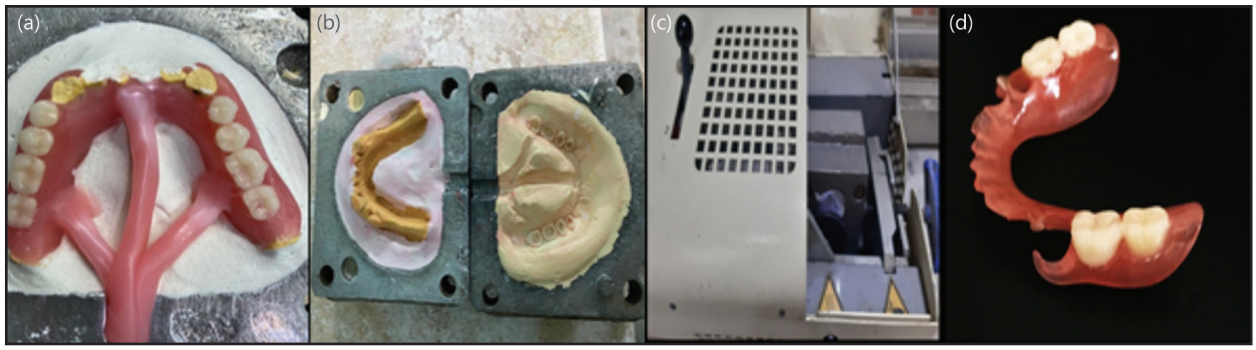

Fig. (2) Fabrication of karadent removable partial framework (a) Spruing for karadent denture; (b) Denture flasking; (c) Thermopress 400 automatic air injector; and (d) Final Karadent RPD.

Radiographic Evaluation

a. Marginal bone height measurement for distally extended ridge

The digital CBCT radiograph machine (Scanora 3DX) were used and the amount of marginal bone height was determined by the help of OnDemand Cybermed software program. Marginal bone height was recorded and calculated using a scaled ruler on the software from a point about 10 mm distal to the mental foramen to the crest [13]. This distance was calculated in millimeters using straight line tool of the system. Any changes in these measurements along the successive follow up periods denoted bone resorption (**Figure 3a**).

b. Assessment of distal crestal bone loss of the abutment teeth:

In the digital CBCT radiograph crestal bone level distal to the abutments was examined. The horizontal line of the cross arch in the panoramic view was moved to touch the superior border of the mental foramen then a vertical line is drawn tangential to the distal surface of the root of the distal abutment and extended to touch the distal crestal bone of the abutment [14]. This distance was calculated in millimeters using straight line tool of the system. Any changes in these measurements along the successive follow up periods denoted bone resorption (**Figure 3b**).

c. Bone width measurement:

In the digital CBCT radiograph the bone width was recorded and calculated using a scaled ruler on the software at a point located 7 mm above the superior border of the mental foramen [15]. The measurement was done between the buccal and lingual aspects of the mandible at this point and calculated in millimeters using straight line tool of the system. Any changes in these measurements along the successive follow up periods denoted bone resorption (**Figure 3c**).

Radiographic evaluation were carried out for every patient at insertion, and at different follow up intervals (6 and 12) months from denture insertion. The results were tabulated and statistically analyzed. For all the readings of radiographic bony changes in each interval (0, 6, 12), readings were recorded for the right and left sides individually then the mean of the bony changes as all were calculated for each interval in both groups

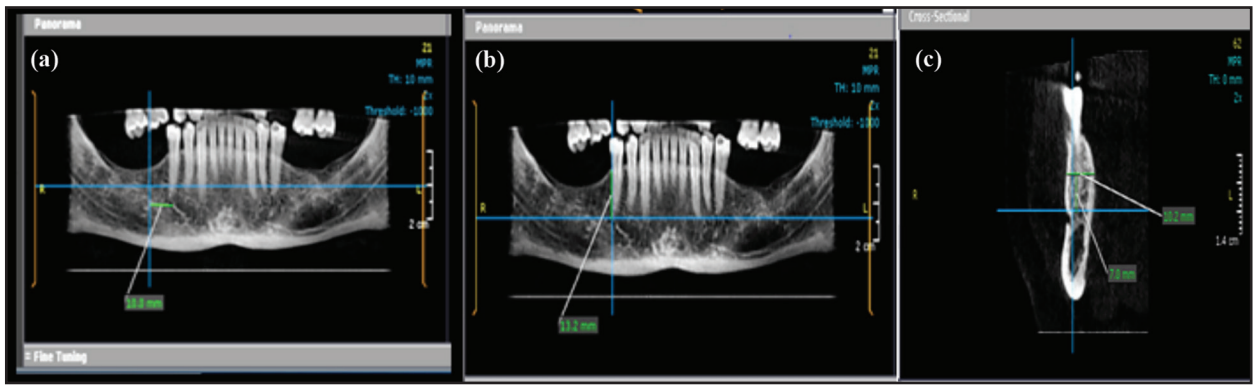

Fig. (3) Image analysis showing (a) Marginal bone height measurement; (b) Assessment of distal crestal bone changes of the abutment teeth; (c) Bone width measurement.

RESULTS

Data were presented and differences were assessed. Paired samples t-test, ANOVA was used to study and compare the changes between the two groups. The significance level was set at $p \leq 0.05$ and highly significant at $p < 0.01$.

From Table (1) and Figure (4), there was an increase in the bone resorption rate of the supporting structures in all follow-up intervals for both groups of the study. The highest increase in the bone resorption rate measurements was observed in (GI) the karadent framework group. The differences between the two studied groups were statistically non-significant at the all intervals of the follow up periods (at $p > 0.05$).

Table (1) *The radiographic changes in the supporting structures in both Vitallium and Karadent groups during all observation periods*.

Intervals	Radiographic changes in the supporting structures		Independent samples t-test
	Group I	Group II	*p*-value
0	15.13 ± 1.48 a	15.60 ± 1.08 a	>0.05 ns
6	14.80 ± 1.45 a	15.20 ± 0.97 a	>0.05 ns
12	14.38 ± 1.38 a	14.45 ± 0.61 a	>0.05 ns
ANOVA	>0.05 ns	>0.05 ns	

Two-way ANOVA

Source of variation	F-ratio	*p*-value
Corrected model	0.919	>0.05 ns
Section	1.90	>0.05 ns
Group	0.601	>0.05 ns
Section x Group	0.10	>0.05 ns

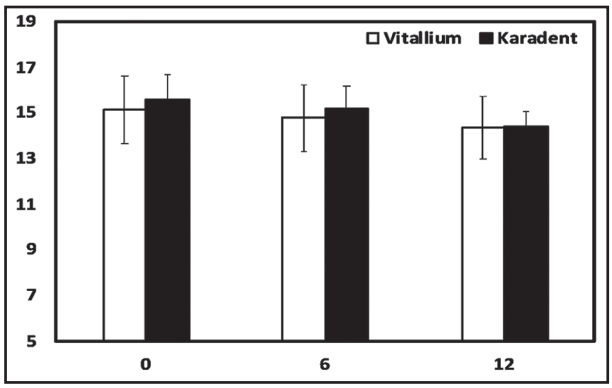

Fig. (4) Bar chart presenting the differences in radiographic change in the supporting structures between the two groups.

DISCUSSION

Patients were chosen of mandibular class I Kennedy classification whom indicated for removable partial denture as they are the frequently present in the dental clinics and the most frequently encountered partial edentulism with higher prevalence in the mandible than the maxilla. Also most of the problems are present in such cases due to nature of the mucosa that provides different support to the denture and limited denture bearing area. Such cases require more accurate prosthodontics

rehabilitation for preserving the remaining teeth and residual ridge [16].

In this study, patients were selected with the remaining teeth extending from the 2nd premolar of one side to the 2nd premolar of the other side. Premolars were chosen as abutments because they are more resistant to rotational displacement and resist the anterior displacing forces due to the buttressing of bone anterior to it. When mandibular bilateral distal extension is symmetrical so the length of the residual ridges were equal, therefore the long axis of denture base is perpendicular to the axis of rotation [17].

Clinical examination was done to verify patients with healthy well-formed residual ridges covered by healthy, firm mucosa to provide adequate and stable tissue support during the study periods. It was reported that, flabby ridge provide easily displaceable tissues, that allows excessive lateral displacement of the prosthesis and adversely affect the support, retention and stability, while keratinized tissues withstand mechanical forces within physiologic limits and reduce the potential for tissue ward movement of distal extension bases and be capable of resisting the occlusal forces and lateral displacement to a large degree when vertical and horizontal stresses are placed on it [18].

Angles' class I maxillo-mandibular relationship was chosen in this study to minimize unnecessary occlusal stresses that are induced by class II and class III maxillo-mandibular relationship. Moreover, cases with sufficient interarch space were chosen, to allow adequate arrangement of artificial teeth, where prosthetic management of partial edentulism can be challenging with the presence of limited interocclusal space, making prosthetic treatment impossible [19].

The selected patients were free from any systemic diseases that affects bone resorption or gingival health and prognosis. Diabetic patients were excluded from this study because of altered bone and mineral metabolism in diabetics that may increase susceptibility to periodontal diseases and inflammatory tissue destruction. Patients with metabolic and endocrinal diseases were also excluded as it causes abutment alveolar bone loss. Patients are also free from localized bone diseases such as osteoporosis to avoid poor prognosis [20].

The crestal bone loss was measured from the distal aspect as in distal extension removable partial denture the excessive torqueing forces act on the abutments distally towards the edentulous area by time lead to distal wall resorption and tooth movement, as More than 90 % of the osteoclasts were observed in the areas with strain intensity higher as stated in a previous study [21].

The null hypothesis was rejected based on the obtained results because the radiographic assessments in this study detected that the radiographic bony changes in the supporting structures in vitallium was lesser than that caused by karadent, but when comparing between the vitallium and karadent RPD during the follow up period in each group, the mean radiographic bony changes showed non-significant difference between the two groups. These results was in accord with other studies stated that the metallic RPD appears to make less adverse effect on the residual ridge in Kennedy Class I partially edentulous patients than thermoplastic ones. Also, that non-metal clasp dentures with clasps are made of the same material of the prosthetic base can cause greater damage to supportive tissues including abnormal resorption of the alveolar bone, the absence of a metallic support and large displacement caused by flexible bases on the supporting tissues can lead to acceleration of alveolar ridge resorption [22].

Another study used three dimensional finite element analysis to evaluate stress distribution in tooth supported removable partial denture fabricated using two different materials, cobalt chromium and a thermoplastic one revealed that the areas of maximum stress were seen in the residual ridge in both models, however, the Cobalt-Chromium model showed significantly lesser stress as compared to the thermoplastic model [23].

Another study supporting the results of this study stated that a properly designed major connector should be rigid to distribute the forces throughout the arch and reducing load concentration while controlling movement of the prosthesis, as the flexible major connector causes injury to the residual ridges and impingement of underlying tissues, resulting in greater bone loss [24].

On the other hand, a study compared the Von-Misses-stress distribution applied to the edentulous ridges from a polyamide RPD with those from a cobalt-chrome, it was stated that polyamide bases can be flexed due to the applied forces and the forces can be distributed in them. So that it can transfer very slight stresses to the underneath surfaces compared to Cobalt-Chrome RPD. So, thermoplastic mandibular distal extension removable partial denture material was superior to vitallium material regarding the preservation of abutment alveolar bone [25].

Despite of that this study was an in-vivo study and has been introduced a new denture base material to the dental field, constructed and used opposing full set of natural dentition, but there were some limitations in the study, firstly, ignoring the importance of estimating the presence or absence of a stress-breaking effect in the karadent RPD on the distal abutment, which could be detected if the radiographic bony changes on the distal extension residual ridge were calculated separately from the radiographic bony changes on the distal crestal bone of the abutment teeth during the successive follow up periods, then tabulated and statistically analyzed separately instead of merging the obtained records as a whole radiographic bony changes. Another limitation includes that, the total sample size was better to be increased over 20 samples for a more accurate result.

CONCLUSION

Based on the limitations of this study, it could be concluded that the karadent frameworks recommended in distal extension RPD cases seeking for esthetics, but it has an adverse effect on the supporting bone in Kennedy Class I partially edentulous patients than cobalt chromium RPD.

RECOMMENDATION

The thermoplastic PRD lacks an important factor of the traditional PRD, in particular, a rigid framework. Therefore, the recommendation of this study is to reinforce it with metal (hybrid design) to provide the PRD with sufficient rigidity with a metallic major connector and sufficient support with metallic rests and to compare its effect on supporting structure of distally extended cases with cobalt chromium RPDs.

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