Comparing Between Two Different Fillers To Improve The Radiopacity And Aesthetics Of Denture Base Materials

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Abstract: Poly (methyl methacrylate) (PMMA) is the material of choice for denture base construction. In spite of its many good qualities, the application of PMMA as an ideal dental base material is still restricted by a few limitations. These limitations can be overcome by adding additives such as fibers and fillers into the polymer matrix to form polymer composites. The aim of this study was to shine a light on the ways and methods of improve some properties of the PMMA denture base materials since it is not considered an ideal material for constructing denture bases. One of the ways of improving the denture base is by adding fillers to the acrylic resin. It was concluded that, the addition of these fillers at suitable amount to PMMA significantly improved the radiopacity of PMMA composite. Also, each filler showed some different effects on the composite especially the aesthetics.
Keywords: PMMA, Fillers, Denture Base, Reinforce.

المقارنة بين حشوتين مختلفتين لتحسين القدرة الإشعاعية والمظهر الجمالي للبوليمر المادة الأساسية لقاعدة أطقم الاسنان

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المستخلص: يعتبر البولي (ميثاكريلات الميثيل) (PMM) هو المادة المفضلة لبناء قاعدة طقم الأسنان المتحرك. على الرغم من صفاته الجيدة العديدة، فإن تطبيق PMMA كمادة أساسية مثالية للأسنان لا يزال مقيدًا ببعض القيود. يمكن التغلب على هذه القيود عن طريق إضافة مواد مضافة مثل الألياف والمواد المالئة إلى مصفوفة البوليمر(Fillers) لتكوين مركبات البوليمر. كان الهدف من هذه الدراسة هو تسليط الضوء على طرق وأساليب تحسين بعض خصائص المواد الأساسية لأطقم الأسنان PMMA .حيث أنها لا تعتبر مادة مثالية لبناء قواعد أطقم الأسنان. إحدى طرق تحسين قاعدة طقم الأسنان هي إضافة (Fillers) إلى بودرة الأكريليك. كانت النتيجة أن إضافة هذه الحشوات بكمية مناسبة إلى PMMA تحسن بشكل ملحوظ القدرة الإشـــعاعية لمركب PMMA. كما أظهرت كل مادة من المواد التي تم دمجها بعض التأثيرات المختلفة على المركب وخاصـــة المظهر الجمالي.

الكلمات الدالة: PMMA، الحشوات (Fillers) ، قاعدة طقم الأسنان، التعزيز.

Introduction:

One of the normal phenomena in human life is that may be loses the teeth due to certain reasons. This should make them think on how to rectify and solve the problem. One of the most important needs for patients attending clinics to restore esthetics and/or function (Zafar, 2020). The majority of this restoration technique is using removable dentures. Hence, the most of its important part is the base. For that reason, it should have special properties such as longer retention, and stability in the mouth environment (Sharma and Shashidara, 2014). There are various materials being used as denture base such as Porcelain, Bone, Wood, Vulcanite dentures

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and Aluminum (Tandon et al., 2010). Among of these materials, poly methyl methacrylate (PMMA, it becomes the major polymeric material used as a denture base material. However, the denture based fabricated from PMMA still has some problems to address such as insertion in undercut areas, brittleness which leads to fracture, and allergy to PMMA. (Sharma and Shashidara, 2014).

PMMA has achieved its popularity as main denture base material is due to several factors; including easy manipulation and processing, fabrication with affordable equipment, aesthetically appealing, and biocompatibility.

PMMA is also light in weight, low cost, biocompatibility, ease of processing, stability in the oral environment, and acceptable aesthetics (Alla et al., 2015) besides colour matches that of the gingival tissues. However, this material is not ideal, especially on the radiopacity properties. It's still not yet addressed this problem properly (Shawi et al., 2022).

However, PMMA denture bases are brittle and weak, they have a propensity for mechanical failure, leading to a risk of fracture. Maxillary dentures are at risk of midline fracture. The majority of fractures result in the mouth during normal function. This phenomenon can be attributed to the resin fatigue that results from deep scratches and stress intensification (6). Several studies have been conducted with the goal of enhancing the properties of PMMA by incorporating fillers and fibers in its composition (Rahme et al., 2005), (Alla et al., 2015), (Aldabib etal., 2021).

There are many examples for ceramic fillers. Zirconium oxide (ZrO_2) filler has effect on the most properties of polymer composite such as, impact strength, fracture toughness and hardness. (Saridag and Alniacik, 2013), (Kundie et al., 2018), (Gad et al., 2017) reported that adding TiO_2 particles could improve the fracture toughness, hardness of PMMA, as well as thermal conductivity. The other example for filler is hydroxyapatite (HA**).** (Zebarjad et al.,2011) reported on the mechanical properties of PMMA with HA nanocomposite to observe that wear rate decreased by increasing in HA filler. (Poyrazl et al 2021) said that, the applicability of a variety of filler as a reinforcing agent in polymer composites may change depending on filler types. There are other fillers being used for the PMMA denture base applications.

One of very essential properties dental materials is radiopacity property. (Rawls et al., 1990) reported that removable appliances such as complete and partial dentures, night guards and the like have the potential to be accidently dislodged and find their way into the body, requiring surgical removal. Because of that it is important of most of dental material to have sufficient transparency. Dentures constructed from acrylic resin are radiolucent because it is comprising C, O and H atoms that are poor X-ray absorbers. This is a serious disadvantage of these materials. If a patient swallow or inhales a denture or fragment of a denture it is difficult to detect using simple radiological techniques (McCabe and Walls, 2008).

Therefore, the aim of this study is to improve the radiopacity of the PMMA denture base material. (Tirapelli et al., 2004) stated that the filler contains of glass and ceramic particles that give radiopacity to the composite. These particles might differ significantly in their concentration and composition, and therefore the radiopacity of composites varies as well.

Materials and methods:

The solid matrix consisted of PMMA with high molecular weight (966,000 GPC– Aldrich U.S.A). The liquid component comprised of methyl methacrylate (MMA) (Fluka UK), stabilized with 0.0025% hydroquinone. The enamel and dentine powder had selected as a filler. 15 g of each filler powder and 10 wt % of PMMA are mixing together then were added into

MMA. The blending of powder to liquid (P/L) was done according to standard dental laboratory usage (ISO, 2001).

After reaching the dough stage, the mix was packed into a mold and was pressed under 14 MPa, at room temperature for 30 min. The final polymerization (curing process) was carried out in a water bath at 78ºC for 90min before the mold was left to cool slowly at room temperature. After that, the samples were removed. The reinforcing fillers are enamel and dentin were selected.

Since the radiopacity of dental materials is defined as an optical density value which converted into an equivalent aluminum (eq Al) thickness value (in mm), the radiopacity test was evaluated according to (ISO, 4049) (E). The experimental procedure was carried out as follows; the tested samples, aluminum plate and films were irradiated with X-ray at 60 kV using X-ray machine TOSHIBA KXO-15 R, Japan at target film distance of 35cm, the exposure time was 1mAs. The film was developed and fixed using Kodak X-OMAT 5000 RA Processor machine.

Radiopacity Evaluation Test

According to (ISO,2000) all the samples should be compared to the aluminum plate. Figures 1 shows the results of the radiopacity test of the PMMA matrix samples and the composite samples compared with aluminum plate. It can be seen that the formulations containing 15% ceramic filler is more visible compared to the PMMA matrix sample. Moreover, it can be noted that by adding ceramic filler into the denture base material resulted in a significant improvement in radiopacity. Hence, it is possible to increase the radiopacity of the denture base by increasing the filler loading. However, by increasing the filler loading can lead to undesirable effects such as reduction in the mechanical properties (Mohamed, 2005).

Figure1: X-ray of the flexural samples compared to the aluminium plate.
(A) Aluminium plate (C) PMMA + enamel filler 15 wt %
(B) PMMA matrix (D) PMMA + dentin filler 15 wt %

The percentage of filler 15% was in agreement with one made by (Elshereksi, 2006) who concluded that, the addition of barium titanate filler into the denture base material resulted in a considerable improvement in radiopacity. Also, this was in agreement with (Shawi et al., 2022) who tried to improve the denture base materials with α-cordierite ceramic filler compared to the PMMA matrix sample. They said that, adding α-cordierite ceramic filler into the denture

base material resulted in a significant improvement in radiopacity. Especially, in the sample which contains 15 wt% of filler. As showed in figure 2, these particles might differ significantly in their concentration and composition, and therefore the radiopacity of composites varies as well. Also, (Abudalazez, 2019) said another explain about that. He stated that happened because the good distribution of atoms of fillers.

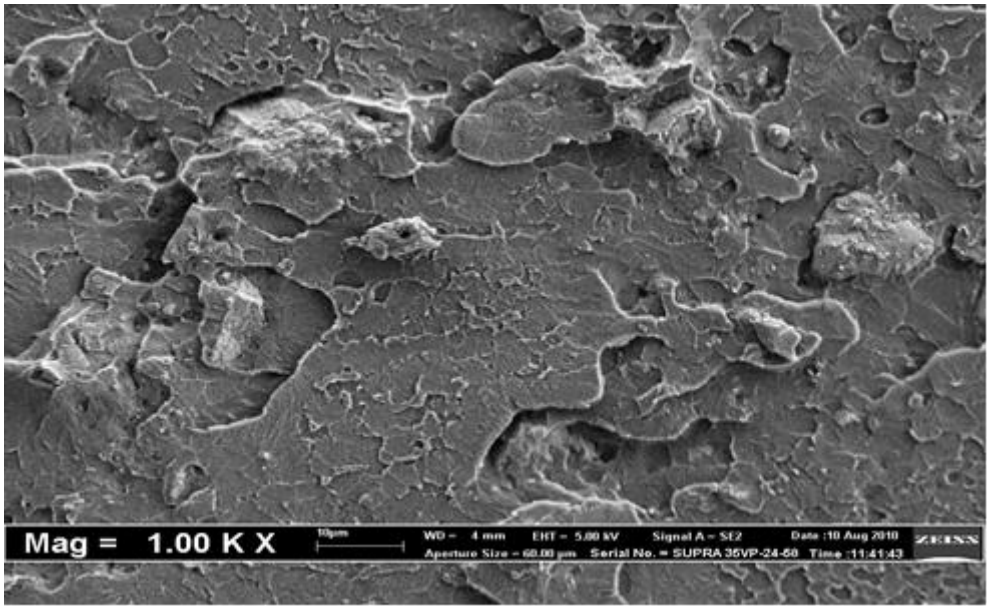

Figure (2): SEM micrograph of the fracture surfaces of the 15 wt% (α-cordierite-filled) PMMA matrix at 1000x magnification. The filler particles are embedded and semi-bonded to the matrix. (Shawi et al., 2022)

THE EFFECT OF INCORPORATION OF FILLERS ON AESTHETICS:

The aesthetics of a dental restoration depends on the chosen material, anatomical form, surface texture, translucency and colour. This means that, to accurately reproduce the appearance of a natural tooth, considering the patterns of reflection and absorption of the light is not an easy task (Abdalazez, 2019). As mentioned earlier, ceramics have been widely used in dentistry because of their ability to provide excellent cosmetic results that mimic natural teeth. They are biocompatible, allow adequate reflection and transmission of light, and they exhibit good mechanical strength when subjected to masticatory efforts (Holloway and Miller, 1997). The rapid development of ceramic systems and processing enabled the treatment of teeth in both the anterior and posterior areas, with the primary objectives of properly restoring form, function and aesthetic excellence without the presence of metal.

In our research, when applied two types from ceramic fillers, it found that there is not any bad effect on the denture. In addition, the two dentures which added to them the fillers, it improved the colour compared with the original one that made from acrylic only without any additions. It was found that, two dentures which include the fillers more chine than that of PMMA matrix (figures 3,4,5).

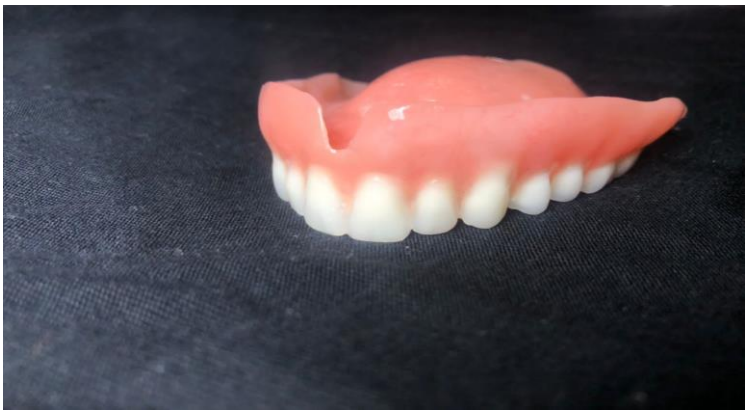

Figure 3: Denture with enamel as a filler.

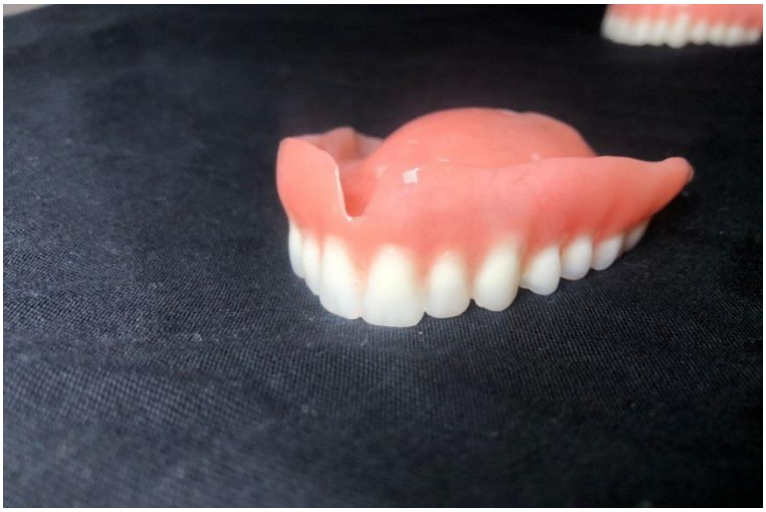

Figure 4: Denture with dentine as a filler.

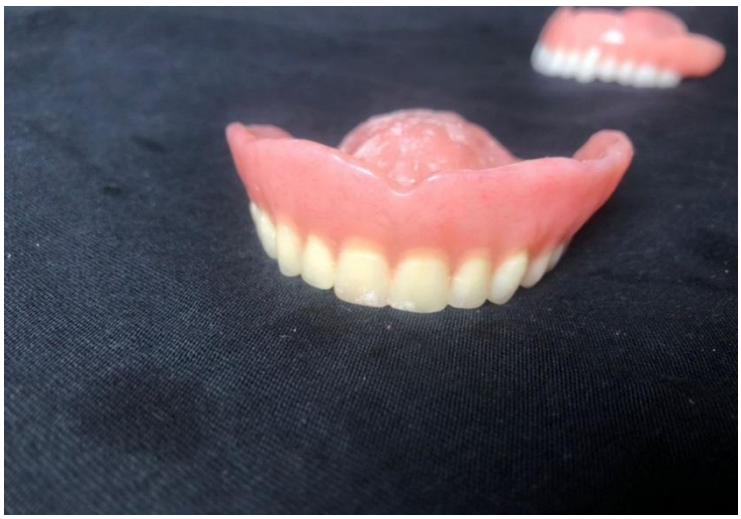

Figure 5: Denture made from PMMA only.

Also, there is no any changes in the all the properties of the dentures such as, retention, stability, good bonding of the base to the teeth and strength of the base. Because of, the ability of ceramics to match the natural dentition and their appropriate physical and optical properties have made

this material the first choice for aesthetic restorations. Some studies stated that, the translucency of ceramics has been emphasized as a primary factor in achieving adequate aesthetic out comes. Nonetheless, although glass-ceramic offers adequate optical properties, it is sometimes unable to mask darkened substrates because of its translucency. In these situations, all-ceramic systems with greater opacity and crystalline phase content should be used, since they provide greater masking ability. Several different ceramic systems, designed to improve the final appearance of definitive all-ceramic restorations, have been described in the literature. However, it is a challenge for clinicians to select a ceramic system with the ability to mask the underlying substrate and match the appearance of ceramic with patients' natural teeth, irrespective of differences in substrate color (Radaelli et al., 2016).

CONCLUSIONS

Within the limitation of this study, it is found that:

i.The addition of fillers leads to enhancement in the most properties of denture base resin material.

ii.Ceramic fillers (at 15 wt% loading) could be the best type of fillers that play a central effect in improved the resin's properties.

iii.The ceramic fillers used showed a pleasant good effect on the aesthetic of the patient appearance.

RECOMMENDATIONS

Other possible properties to evaluate include mechanical, fatigue and wear properties. An evaluation of the effect of a sudden force to the samples under impact test is also suggested in order to determine the brittleness of the materials under this situation. Beside these, the effect of the residual monomer into mechanical, physical and biological properties of the final product can also be conducted. It is also recommended that investigation on the particles size and their dispersion effects on the mechanical properties can be conducted.

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