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Comparative Study on Type II Gypsum and Heat Cure Roughness in Ammonium Bicarbonate Solution

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Abstract

Background: The chemical decomposition of POP idols using an NH_4HCO3 solution produces valuable products with efficient use of ammonium and without any negative effects.**Aim:** To evaluate the dissolution of type II $CaSO_4$ .2 H_2O & its effect on SR of HC-AR immersed in different concentrations of NH_4HCO3 solution. **Material & method:** A total of 40 samples were included with 4 groups A,B,C,D . Group D was control with distal water while group A,B,C with 1:1,1:2 and 1:3 concentration of NH_4HCO3 , POP and 150 ml of water. **Result:** We discovered a statistically non-significant change seen in surface roughness on inter comparison of groups of acrylic plates arch in all groups, namely A, B, C, and D, at various time intervals (i.e., 0 to 12 hrs and 0 to 48 hrs). **Conclusion:** No change regarding SR on HC-AR at diiferent times for type II POP.

Keywords: POP, type II, NH_4HCO3, different concentration, SR, HC-AR, dissolution, $CaSO_4$,concentration , distal water.

1. INTRODUCTION

Dentistry is an area of healthcare that is heavily impacted by the materials and equipment used. Prosthodontics is a specialist branch of dentistry that focuses on diagnosing, arranging treatment, rehabilitating, and maintaining the oral function, comfort, appearance, and health of patients with clinical disorders caused by missing or deficient teeth and/or facial tissues. This is accomplished with the use of biocompatible alternatives.[1] These models are produced by using impression material to make a negative impression of the patient's teeth that are absent, sometimes referred to as a dentulous or edentulous arch. The unfavorable impression is then transformed into a positive reproduction of the patient's dental arch using the dental plaster or plaster of Paris procedure. These models are crucial for the fabrication of prostheses, planning treatments, and making diagnoses. After the prosthesis has been created, dentists and prosthesis technicians have a major challenge in safely removing dental plaster without causing any harm to the prosthesis. This technique is characterized by its time-consuming and labor-intensive nature. As a result, the prosthesis will not fit the patient accurately or correctly. Denture is mainly divided into 2 major categories i.e. complete denture and partial denture. Acrylic resin, which is used in the construction of the denture, has a formidable propensity to adhere to any surface if a separating agent is not applied in the appropriate manner.[2]

Immediately after the completion of the try-in procedure, the waxed trial denture is placed inside a flask using dental plaster, which is a substance that is often used for investment purposes. After that, the final denture operation is finished at this point. [3] During the process of recovering the denture after the processing has been finished, the investment material can be seen clinging to the intaglio as well as the polished surface of the denture. Traditionally, this plaster is removed using mechanical methods such as rotary burs, chisels, and mallets. This process, in turn, causes damage or alteration of the tissue or intaglio suface of the denture, which may further alter the fit of the denture. [2] Dr. Masif, a scientist at the National Chemical Laboratory (Council of Scientific and Industrial Research), developed a solution to the increasing problem of river pollution caused by the immersion of POP idols during Ganesh Visarjan. She discovered that Ammonium Bicarbonate(NH_4HCO3) can dissolve POP in water, resulting in a byproduct that can be used as fertilizer. The solid waste can then be utilized in cement manufacturing.[4] We assessed the ideal concentration level and the quantity of plaster required to dissolve the POP during the first part of the experiment. We conducted this mostly using our study, using these findings as the main source. The actual difficulty, however, is removing the plaster without compromising the acrylic denture's base. This task is going to be completed in the second part of the study, in which we are going to analyze the effects that varying concentrations of the acrylic solution have on the acrylic denture base material.

AIM

To compair & analyse the dissolution of type II gypsum product ($CaSO_4$ .2 H_2O) and its effect on surface roughness(SR) of heat cure acrylic resin(HC-AR) immersed in different concentrations of NH_4HCO3 solution.

2. MATERIALS AND METHOD

In our research we have done an in-vitro study at the department of prosthodontics and crown & bridge, KIMS, Karad, Maharashtra.

Material

The following materials, equipment and instruments were used for the study:

1. Trevalon High impact Heat-polymerized acrylic resins (Dentsply India Pvt Ltd)
2. Dental plaster(Gem stone Shruti Products Uma Kapadia Society, Upleta, Rajkot, Gujarat)
3. Ammonium bicarbonate powder 1kg (AGRA PHARMACEUTICAL LABORATORIES)
4. Surface roughness (Ra) profilometer (Mitutoyo SJ-210, Mitutoyo Corporation, Tokyo, Japan)
5. silicon mould (classic moluds manufacturer)
6. Weighing machine (SF-400 capacity : 1000g×1g/353oz×0.1oz)
7. Mould with slots (Avinash Steel Engineering and company, Karad)
8. Heat cure acryliser machine (Wassermann Dental Maschinen) Gloves
9. Petroleum jelly
10. Porcelain Jar – Jabbar and company
11. Spatula
12. Plaster disc making silicon mould (classic moluds manufacturer)
13. 4 glass beakers with capacity of 250ml
14. Digital thermometer.

METHODOLOGY 1st PART

A total of 36 samples units/ disc rounded to 40 dics (i.e. 10 samples in each 4 groups) would yield 80% poert to detect significant difference , with effect size of 0.6 & significance of 0.05. Group A with solution concentration of NH_4HCO3 1:1, group B with 1:2, group 3with 1:3 with amount of POP dissolved 150 ml of water and control group with solution containing distilled water.

METHODOLOGY 2nd PART

A total of 40 sample of acrylic (10 samples per group , total 4 study groups based on concentration) would yield 80% power to detect significant difference, with effect size of 1.1 & signifinance level at 0.05. Group A with solution concentration of NH_4HCO3 1:1, group B with 1:2, group 3with 1:3 with amount of POP dissolved 150 ml of water and control group with solution containing distilled water. The average weight of the plaster to be dissolve was consider from the first part of study which was 16gm and the solution were prepared.

STASTISTICAL ANALYSIS

It was done using SPSS version 21 , descriptive quantitative data was expressed in mean and standard deviation . Data was checked using shapiro-Wilk test. Confidence interval is set at 95% and probability of alpha error (level of significance) set at

5%.Power of the study set at 80%. Comparison was found using ANOVA test.

3. RESULT

NH_4HCO3	0 hrs Mean (SD)	6 hrs Mean (SD)	12 hrs Mean (SD)	24 hrs Mean (SD)	48 hrs Mean (SD)	P value 0 to 12 hrs)	P value (0 to 48 hrs)
Group A (1:1)	15.8 (1.03)	12.6 (1.64)	10.3 (1.15)	7.6 (0.69)	0.0 (0.0)	p<0.001**	p<0.001**
Group B (1:2)	14.9 (0.73)	9.5 (0.84)	5.9 (0.87)	0.0 (0.0)	0.0 (0.0)	p<0.001**	p<0.001**
Group C (1:3)	14.7 (1.05)	13.4 (1.26)	11.2 (1.22)	7.7 (2.0)	0.0 (0.0)	p<0.001**	p<0.001**
Group D (Distilled Water)	14.4 (1.26)	15.9 (0.87)	15.7 (0.82)	15.2 (0.91)	15.8 (0.78)	p >0.05	p>0.05

TABLE 1: INTRA-GROUP COMPARISON

On our evaluation in table 1, at different hours ((i.e 0 to 12 hrs and 0 to 48 hrs) NH4HCO3 we found that group A,B,C showed stastistically highly significant difference as the p value was <0.001 each respectively . Whereas, distal showed stastistically non significant difference as the p value was >0.05.

	Pairwise comparison using Tukey's post hoc test				
NH_4HCO3	0 hrs Mean (SD)	6 hrs Mean (SD)	12 hrs Mean (SD)	24 hrs Mean (SD)	48 hrs Mean (SD)
Group A (1: 1)vs Group B (1: 2)	p =0.232	p<0.001**	p<0.001**	p<0.001**	p =1.000
Group A (1: 1)vs Group C (1: 3)	p =0.103	p =0.456	p =0.229	p =0.997	p =1.000
Group A (1: 1)vs Group D (Distilled Water)	p =0.024*	p<0.001**	p<0.001**	p<0.001**	p<0.001**
Group B (1: 2)vs Group C (1: 3)	p = 0.973	p<0.001**	p<0.001**	p<0.001**	p =1.000
Group B (1: 2)vs Group D (Distilled Water)	p = 707	p<0.001**	p<0.001**	p<0.001**	p<0.001**
Group C (1: 3)vs Group D (Distilled Water)	p =0.917	p<0.001**	p<0.001**	p<0.001**	p<0.001**

TABLE 2: PAIRWISE COMPARISON

In our research table 2, upon comparison of A & B group we found statistically highly significant difference in the dissolution rates at six hours, twelve hours and twenty-four hours with a p value < 0.001 while at forty-eight hours statistically insignificant difference. Group A & C, showed a statistically insignificant difference in the dissolution rates at six hours, twelve hours, twenty-four hours and forty-eight hours with a p value of 0.456, 0.229, 0.997,1.000. Group A & D showed a statistically significant difference in the dissolution rates at six hours, twelve hours, twenty-four hours and forty-eight hours with a p value<0.00. Group B & C showed a statistically highly significant difference in the dissolution

rates at six hours, twelve hours and twenty-four hours with a p value < 0.001 while at forty-eight hours statistically insignificant difference. Group B & D showed a statistically significant difference in the dissolution rates at six hours, twelve hours, twenty-four hours and forty-eight hours with a p value<0.001 and group C & D showed a statistically significant difference in the dissolution rates at six hours, twelve hours, twenty-four hours and forty-eight hours with a p value<0.001.

	0 Hours Mean (SD)	12 Hours Mean (SD)	**p value (Paired t test)**
Group A (1:1)	**2.23 (0.44)**	**2.23 (0.44)**	**P =1.000**
Group B (1:2)	**1.07 (0.16)**	**1.07 (0.16)**	**P =1.000**
Group C (1:3)	**2.26 (0.69)**	**2.26 (0.69)**	**P =1.000**
Group D (1:4)	**2.25 (0.55)**	**2.25 (0.55)**	**P =1.000**

TABLE 3: COMPARISON ON SR of AR in NH_4HCO3

In our research in table 3, at different time(i.e 0 to 12 hrs and 0 to 48 hrs), we found a statistically insignificant change in surface roughness of acrylic plates placed in all groups i.e., A,B,C and D at different time intervals.

DISCUSSION

Dentistry, which is the medical science discipline that makes the greatest use of equipment and materials, is responsible for providing patients with the best possible treatment. Over the course of several decades, digital technology has made significant strides, resulting in a significant improvement in the precision and effectiveness of dental procedures. Philipp Pfaff, a German dentist who lived from 1713 to 1766, was the first to use plaster. He describes in his thesis, "Abhandlung von den Zhnen," the process of creating an impression of the jaw by first filling it with plaster and then using sealing wax to create the impression. A significant advancement in dental technology, Pfaff's technique established the indirect approach as the gold standard for prosthesis manufacturing.This was a significant stride forward.[5] A study was conducted over the course of time with the intention of improving the compressive strength of plaster as well as lowering its setting expansion, which was dependent on the water-powder ratio. These studies increased the efficacy of dental plaster in the field of dentistry and enhanced its properties. They used mechanical methods (such as rotary burs and sandpaper) to remove dental plaster that sticks to the acrylic denture base or intaglio surface of the prosthesis, despite all of these technological and material breakthroughs. [2]

Furthermore, Ammonium bicarbonate is an inorganic compound with formula (NH4)HCO3, simplified to NH5CO3. The compound has many different names used in general population. Most commonly used name is baking soda. Chemically speaking, it is the bicarbonate salt of the ammonium ion. It is a colourless solid that degrades readily to carbon dioxide, water and ammonia. Ammonium bicarbonate is produced by combining carbon dioxide and ammonia:[6]

$$CO2 + NH3 + H2O \rightarrow (NH4)HCO3$$

This compound is very widely used in food industry specially for baked food as a leaving agent in small quantity. The other uses of compound includes its use in pharmaceuticals, production of dyes, pigments, and also use in basic fertilizer as the source of NH_3.[6]

In another study, it was not possible to determine the concentration of ammoniacal nitrogen (NH3-N), because there was a significant amount of deviation in the numbers. According to their results, it was 0.439. and 0.637 mg/L in the non-diluted sample of POP 02 after immersion. On the other hand, the value of the $(SO4)^{-2}$ concentration shows a quick increase. by use of a solution of (NH4)HCO3), after the chemical decomposition of POP idols.[7] Before immersion, the concentration of $(SO_4)^{-2}$ was 9.56 mg/L during the first phase. However, following the reaction in the non-diluted sample POP 02, the concentration of sulphate increased to 14,3603 mg/L. As a result of the reaction between (NH4)HCO3 and POP, the quantity of $(SO_4)^{-2}$ has steadily grown.[7] Specifically, in another study CO_2 was produced in the form of bubbles during the conversion of $Ca_2\,SO_4$ to $(NH4)_2SO4$ and CaCO3, as shown by a lime water test.[8]

In a study reseachers concluded that upon diluting to proper concentration, this important $(NH4)_2SO4$ may be used in fields and green belt areas as an important nitrogen sulphur fertilizer for plant growth. The elements of nitrogen and sulphur are both important for the growth of plants since they are engaged in a number of biological processes, one of which is the production of proteins.[9] In accordance with the findings of Craswell et al. (1981), this particular fertilizer is suitable for application in alkaline soil as well as in circumstances that call for the use of the fundamental elements of nitrogen and sulphur. As well as the medicinal, baking, textile, fire extinguishing powder, and wood pulp industries, it has utility.[10] According to Declet (2016), calcium carbonate, which is a by-product that is obtained, has the potential to be utilized as a raw material in the production of chalk, as well as in the construction industry, the metallurgy industry, the chemical industry, and other sectors. It may also be applied in the removal of toxins from the environment.[11] In a study, the authors reported that, after taking into account a particular resin composition, the shrinkage that happens during curing is entirely caused by heat. It makes no difference whether you use a cast or a model; the amount of shrinkage is dictated by the temperature at which the resin becomes hard enough to compress thermally. The most recent study found significant changes in linear dimensions after the curing, finishing, and polishing operations were complete.[12] Acrylic resin has been a highly successful denture base because of its exceptional cosmetic properties, great color stability, and adaptability to be used with a simple denture technique. Despite all these advantages, the lack of dimensional stability in acrylic resin dentures remains a disadvantage.[12] According to Komiyama and Kawara[13], after the denture has been withdrawn from the mold, the stress that is caused by thermal contraction is relieved very immediately. The stress that is caused by the contraction of polymerization, on the other hand, will be relieved in a way that is more gradual. They arrived at the conclusion that the stress that is caused by thermal contraction is of an instantaneous mechanical nature, but the stress that is caused by polymerization takes place on a molecular level and includes polymer chains. Using a vernier caliper that had an accuracy of 0.001 inch before and after curing, Zissis, Huggert, and Harrison[14] inserted steel pins in the wax trial bases and measured the distance from the outside of one pin to the outside of the second pin. This was done in order to determine the distance between the two pins.

Whereas, in our study we have taken different concentration of solution to reduce the time required for the dissolution of plaster and we found that all the groups shows different rate of dissolution but after 48 hours all the three groups shows total dissolution of the plaster, is highly significant compare to control group which shows not significant changes in the weight of the plaster at any interval of time.

4. CONCLUSION

Acrylic resins that have been heat-cured during resin polymerization are going to undergo dimensional changes throughout the polymerization process. Shrinkage and expansion are dimensional changes that occur in acrylic resins that have been heat cured and have an effect on the fit of the denture as well as the occlusal attachment.

Thus, in our study we do not found any significant change regarding the effect on SR of heat HC-AR immersed in different concentrations of NH_4HCO3 solution. More prospective longitudinal cross sectional studies needs to be done to validate the results of our study.

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