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To Evaluate and Compare the Physical Properties of The Currently Available Dental Stone, Improved Variety of Dental Stone and The Polyurethane Synthetic Resin Die Material

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ABSTRACT

Background: The innovative lamp has also kindled and revolutionized dentistry, as a result of which, newer and better materials are being developed consistently. The field of fixed prosthodontics is no exception and has also seen radical changes. New materials are being introduced everyday with increased emphasis on precision. Various types of die materials are available, apart from the most commonly used stones, like polyurethane resins, epoxy resin, electroplated copper, electroplated silver, ceramic, silico phosphate cement, amalgam, self-cure resins etc. each has its own advantages and disadvantage. These conventional die materials have also undergone a revolutionary change and various modified and improved varieties are currently available. These materials exhibit limitations attributed to their inherent microscopic structures. Efforts are on to bring out better qualities in this material. This study was conducted to evaluate and compare the physical properties of the conventional gypsum products with the improvised variety and the polyurethanes, in order to justify their use, for increased precision. Most of the die materials have phased out because of their inferior Physical Properties, sensitivity of the handling technique and time factor involved.

Keywords: Physical properties, dental stone, synthetic resin die material.

INTRODUCTION

The innovative lamp has also kindled and revolutionized dentistry, as a result of which, newer and better materials were being developed constantly. The field of fixed prosthodontics was no exception and has also seen radical changes. New materials were being introduced everyday with increased emphasis on precision. The die was a positive replica which represents a clinical situation. The die material has a tremendous bearing on the success of the final restoration.[1] Various types of die materials were available, apart from the most commonly used stones, like polyurethane resins, epoxy resin, electroplated copper, electroplated silver, ceramic, silicophosphate cement, amalgam, self-cure resins etc. each has its own advantages and disadvantages.[2]

Most of the die materials have phased out because of their inferior physical properties, sensitivity of the handling technique and time factor involved.[3] Gypsum die materials were one of the oldest and most commonly used. They enjoy popularity mainly due to ease of manipulation and economic considerations.[4] These conventional die materials

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have also undergone a revolutionary change and various modified and improved varieties were currently available.[5] These materials exhibit limitations attributed to their inherent microscopic structures. Efforts were on to bring out better qualities in the materials.[6]

The newer polyurethanes were also gaining popularity as die materials. They were predominantly used in various industries and also fabrication of maxillofacial prosthesis. These materials were accurate in reproducibility and have good abrasion resistance.[7]

The development of better materials was not the only aim of any research activity. It was equally important to analyze these materials so as to check whether they were living up to the expectations and the claims made by the manufacturers. It was indeed a herculean task, as it was not possible to achieve that without resorting to the least techniques and state of the art equipment.[8] The study was conducted to evaluate and compare the linear, vertical and physical properties of the available dental stone, improved dental stone and polyurethane synthetic resin die material after 2 hours, 24 hours, and 7 days and to evaluate the Vickers surface micro hardness and the effect of a die hardener on gypsum dies.

MATERIALS AND METHODS

An in vitro study was carried out to evaluate and compare the physical properties of commercially available dental die stone, an improved dental die stone, and a polyurethane synthetic resin die material. The impression material used for the fabrication of various samples was condensation silicone and a commercially available; gypsum die hardener was one of the variables.

Operating Protocol

In the experimental procedure, it the test samples were meticulously manipulated under the same conditions of w/p ratio, soaking time, mixing time, and number. of spatulations. All the samples were then vibrated on a mechanical vibrator while pouring.

The method of manipulation of the die materials was be strictly followed according to the manufacture's instruction were mentioned below.

Table A: Manipulation details.

DIE SAMPLE	WATER	POWDER	SOAKING TIME	MECHANICAL MIXING TIME
P (die stone)	100ML	23gms	30 sec	30sec
Y (improved die)	100ML	23gms	30 sec	30sec

The powder was weighted on Sartorius electronic balance which had a least count of 0.0001 gram. Distilled water was measured with a measuring cylinder having least count of 0.1ml and poured into a clean, dry container of the mechanical vacuum mixer. It was followed by the addition of accurately proportioned measures of powder which was soaked for 30 seconds as per manufactures instructions. The container was assembled on the mechanical vacuum mixer, set for 30 seconds as recommended. After mixing for 30 seconds the contents were poured under vibration into the respective molds for the respective test procedures.[4]

Manipulation of polyurethane resin die samples:

The polyurethane resin die materials used in the study was a two part liquid and a powdered spherical resin filler system. The two-part liquid consisted of component A, a straw colored liquid which was be relatively less viscous than the blue colored liquid, component B.

According to the manufacturer's instructions, half an ounce of component A was squeezed into the measuring compartment and was poured in the disposable mixing cup, to that one level scoop of spherical resin filler was added followed by half an ounce of component B. The mixing procedure was to be carried out thoroughly and carefully with a wide wooden spatula for 30 seconds, avoiding incorporation of air in the mix. Using a thin steady stream, sample B was to be poured in the clean dry impressions under vibration. All the specimens was allowed to set for 2 hours prior to separation. [53]

DIMENSIONAL ACCURACY:

Fabrication of master die:

A stainless-steel master model was machined to stimulate the preparation of three unit fixed partial denture. In the preparation, abutments resemble the first premolar and the first molar with a pontic space for massing second premolar. The abutments were fixed on a square shaped stainless-steel block (35 mm× 20 mm × 5 mm) with a semicircular notch on one side to aid for orientation of the subsequent special trays.[43]

Reference points in the form of depressions which could be reproduced in the impressions were punched on the center of the occlusal surface of each abutment. Two circular reference lines which could be replicated in the impressions were inscribed near the occlusal and cervical ends of the first molar. A 'V' – shaped notch was incorporated at the cervical end of the premolar abutment. The abutment had a shoulder fine wash of 1mm width and a taper 6°.

The dimensions of the reference points were as follows:

A) Inter-abutment dimension between the depressions

R_1 : 14.764 mm (approx. 15 mm)

B) The cervico-occlusal dimensions measured between the inscribed lines

R_2 : 2.762 mm

C) The 'V' shaped notch on the premolar measured

R_3 : 62°

FABRICATION OF SPECIAL TRAYS:

A uniform 2 mm thickness of wax spacer was adapted on the stainless-steel master model. Impression trays were fabricated by molding the tray material with a uniform thickness of 2 mm and having 4 'V' shaped extensions on the sides so as to aid in the orientations of the special trays. The special trays were perforated to facilitate mechanical interlocking of the impression material. The trays were checked for fit on the master die.

IMPRESSION TECHNIQUE:

90 impressions were made using condensation silicon impression with a double mix double stage technique along with the use of 0.5 mm polyurethane sheet as spacer for the light bodied impression material. Of the 90 impressions, 30 each were poured with product die stone, improved die stone, polyurethane resin die material. It was meticulously observed that the products were manipulated under the same conditions of W/P ratio, soaking time, mixing time, number of spatulation, and were vibrated on a mechanical vibrator. The dies were recovered from the impressions after 2 hours.

MEASUREMENTS OF THE TEST SAMPLES:

Measuring the die stone, improved die stone, and polyurethane resin die material with the linear and vertical dimensional accuracy with time interval of 2 hours, 24 hours, and 7 days. And recording the which material were better in dimensional accuracy at an interval of 2 hours, 24 hours, and 7 days. A total 90 measurements were recorded of die stone, improved die stone, and polyurethane resin die material samples. Mean and % changes in dimensions of materials were calculated.

VICKERS MICRO HARDNESS:

Molds of 15 mm internal diameter and 10 mm height were prepared with product condensation silicon impression material. The impressions were placed on a glass surface having a smooth fine wash. A total of 60 molds were prepared, 10 each for products die stone, improved die stone, and polyurethane resin die material. The products die stone, improved die stone, polyurethane resin die material. Were manipulated as discussed earlier and were poured under vibration in their respective molds.

The samples were immediately covered with a glass slab so as to get an even, poly washed, and scratch free surface devoid of any air bubbles. The die stone, improved die stone, and polyurethane resin die material specimens were recovered after 2 hours from the molds and examined for any excess which was then trimmed.

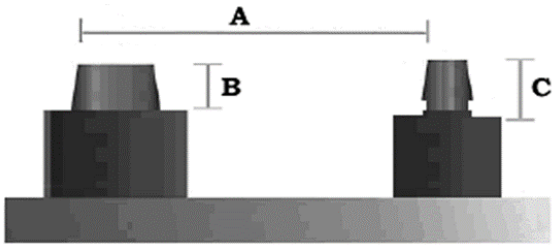
The circular flat surface of die stone, improved die stone, and polyurethane resin die samples were divided into 2 equal parts. One half of the surface was coated with 2 coats of die hardener at an interval of 5 minutes. After each application the surface were carefully and gently blown with dry air

to achieve even spreading of the product die hardener. The specimens were then stored at room temperature.[50]

MEASUREMENTS OF TEST SAMPLES:

Die stone, improved die stone, and polyurethane die resin test samples were tested after a period of 24 hours from the start of the mix. The test specimens were clipped to the object table with the stability of the specimen. The surface was observed under the microscope for any irregularities and voids. After selecting a good filed the object table were rotated in an anti-clock wase direction and indentation were achieved under the load of 200 grams for 30 seconds. The base was then moved in a clockwise direction and the dimensions of the diagonals of the round shaped indentation were measured with eye piece screw micrometer. The procedure was carried out ten times on each specimen, out of which 10 indentations were made on the surface coated with product die hardener and other 10 on the uncoated surface. A total of 60 indentations on each were experimented for die stone, improved die stone, and polyurethane resin die samples. The data was recorded and the Vickers surface micro hardness were calculated.[19]

RESULTS



Graph 1: Dimensional Accuracy

Table 1: Ultra Rock.

Group : Ultra Rock (y)										
Sr. No.	Sample No.	After 2Hours			After 24Hours			After 7Days		
		Dimension A	Dimension B	Dimension C	Dimension A	Dimension B	Dimension C	Dimension A	Dimension B	Dimension C
1	No.1	17.390	5.049	7.025	17.29	5.035	7.002	17.255	4.941	6.872
2	No.2	17.239	5.173	7.100	17.231	4.996	6.906	17.210	4.933	6.895
3	No.3	17.253	5.152	7.163	17.233	4.950	6.901	17.229	4.935	6.878
4	No.4	17.542	5.080	7.044	17.496	4.827	6.855	17.456	4.761	6.763
5	No.5	17.358	4.995	6.919	17.261	4.848	6.714	17.255	4.801	6.676
6	No.6	17.407	4.870	6.790	17.351	4.822	6.550	17.325	4.730	6.532
7	No.7	17.552	5.015	7.038	17.525	4.980	6.961	17.522	4.820	6.740
8	No.8	17.282	5.166	7.071	17.244	5.115	6.993	17.202	4.971	6.879
9	No.9	17.391	5.020	6.979	17.382	4.979	6.943	17.370	4.898	6.855
10	No.10	17.510	4.929	6.961	17.477	4.898	6.918	17.452	4.822	6.803
AVERAGE		**17.392**	**5.044**	**7.009**	**17.349**	**4.945**	**6.874**	**17.327**	**4.861**	**6.798**

Table 2: Kalrock (p)

Group : Kalrock (p)										
Sr. No.	Sample No.	After 2 Hours			After 24 Hours			After 7 Days		
		Dimension	Dimension	Dimension	Dimension	Dimension	Dimension	Dimension	Dimension	Dimension

		A	B	C	A	B	C	A	B	C
1	No.1	17.200	5.002	7.027	17.140	5.036	6.973	17.122	4.976	6.813
2	No.2	17.291	5.102	7.051	17.250	5.006	6.922	17.021	4.970	6.911
3	No.3	17.268	5.100	6.909	17.261	4.951	6.872	17.250	4.841	6.782
4	No.4	17.479	5.052	7.099	17.414	4.928	6.916	17.398	4.906	6.901
5	No.5	17.413	5.012	7.000	17.400	4.933	6.818	17.388	4.916	6.757
6	No.6	17.263	5.193	7.162	17.248	4.999	6.976	17.204	4.978	6.951
7	No.7	17.346	5.139	7.098	17.322	5.132	7.060	17.318	5.029	6.841
8	No.8	17.675	4.936	6.967	17.633	4.903	6.876	17.604	4.833	6.793
9	No.9	17.641	5.167	7.210	17.624	5.068	7.041	17.570	4.898	6.857
10	No.10	17.354	5.230	7.285	17.318	4.925	6.776	17.340	4.905	6.768
AVERAGE		**17.393**	**5.093**	**7.080**	**17.361**	**4.988**	**6.923**	**17.321**	**4.925**	**6.837**

Table 3: Polyurethane Resin (B)

Group : Polyurethane Resin (B)										
Sr. No.	Sample No.	After 2 Hours			After 24 Hours			After 7 Days		
		Dimension A	Dimension B	Dimension C	Dimension A	Dimension B	Dimension C	Dimension A	Dimension B	Dimension C
1	No.1	17.353	4.983	6.963	17.352	4.953	6.879	17.307	4.948	6.81
2	No.2	17.495	5.141	7.111	17.488	5.054	6.995	17.47	5.004	6.984
3	No.3	17.428	4.942	6.976	17.363	4.937	6.95	17.337	4.921	6.937
4	No.4	17.683	4.962	6.969	17.676	4.960	6.909	17.646	4.952	6.889
5	No.5	17.432	4.980	6.981	17.428	4.952	6.972	17.420	4.929	6.968
6	No.6	17.480	4.972	6.995	17.420	4.958	6.938	17.401	4.948	6.931
7	No.7	17.392	4.991	6.983	17.384	4.975	6.95	17.371	4.959	6.938
8	No.8	17.410	4.973	6.999	17.398	4.959	6.981	17.384	4.941	6.975
9	No.9	17.434	4.966	6.984	17.412	4.960	6.964	17.400	4.955	6.943
10	No.10	17.458	4.969	7.001	17.431	4.948	6.993	17.418	4.932	6.929
AVERAGE		**17.456**	**4.987**	**6.996**	**17.435**	**4.965**	**6.953**	**17.415**	**4.948**	**6.930**

Table 4: Comparison by using anova test used

Dimension A	Ultra rock (n=10)		Kal rock (n=10)		Polyurethane Resin (n=10)		p-value
	Mean	SD	Mean	SD	Mean	SD	
2 hours	17.39	0.11	17.39	0.16	17.46	0.09	0.432
24 hours	17.35	0.12	17.36	0.16	17.44	0.09	0.273
7 days	17.33	0.12	17.32	0.18	17.42	0.09	0.243

There was no significant difference between mean dimension A (mm) in group Ultra rock, group Kalrock and group Polyurethane at 2 hours, 24 hours and 7 days.

Table 5: Comparison by using anova test used.

Dimension B	Ultra rock (n=10)		kalrock (n=10)		Polyurethane Resin (n=10)		p-value
	Mean	SD	Mean	SD	Mean	SD	
2 hours	5.04	0.10	5.09	0.09	4.99	0.06	0.035
24 hours	4.95	0.10	4.99	0.07	4.97	0.03	0.423
7 days	4.86	0.08	4.93	0.06	4.95	0.02	0.011

There was significant difference between mean dimension B (mm) in group Ultra rock , Kalrock and group Polyurethane at 2 hours and 7 days.

Table 6: Comparison by using anova test used.

Dimension C	Ultra rock (n=10)		kalrock (n=10)		Polyurethane Resin (n=10)		p-value
	Mean	SD	Mean	SD	Mean	SD	
2 hours	7.01	0.10	7.08	0.11	7.00	0.04	0.108
24 hours	6.87	0.14	6.92	0.09	6.95	0.04	0.219
7 days	6.79	0.12	6.84	0.07	6.93	0.05	0.002

There was significant difference between mean dimension C (mm) in group Ultra rock, group Kalrock and group Polyurethane at 7 days.

Table 7: Pair wise comparwason by using tukey's test p – values tables.

Dimension A		Ultra rock	Kalrock	Polyurethane
2 hours	Ultra rock	-	0.999	0.496
	Kalrock	-	-	0.502
	Polyurethane	-	-	-
24 hours	Ultra rock	-	0.976	0.296
	Kalrock	-	-	0.401
	Polyurethane	-	-	-
7 days	Ultra rock	-	0.994	0.334
	Kalrock	-	-	0.287
	Polyurethane	-	-	-

The fabrication of prosthodontics restorations by using indirect techniques correct and accurate dies are essentials. The working dies must be accurate and should exhibit certain degree of long-term accuracy. The prepared die should resemble the prepared tooth and its precision may get affected by the quality of the die materials. The study was carried out to evaluate and compare the physical properties of die stone, improved dental die stone and polyurethane synthetic resin die material.

In this was study by using a standardized die the linear and vertical dimensional accuracy with time intervals of 2 hours, 24 hours and 7 days and micro hardness was tested using Vicker's hardness test for 30 samples each of die stone, improved die stone and polyurethane synthetic resin die material.

On manipulations it was observed that improved die stone had comparatively a thicker consistency than die stone as the water/powder ratio of improved die stone was less. Due to this was die stone and improved die stone are poured in the respective molds under mechanical vibrator to avoid entrapment of air. In comparison polyurethane resin die material have a high degree of fluidity when mixed.

The dimensional accuracy of epoxy resins and their compatibility with impression material was tested by making impressions of a stainless-steel die having grooves on the occlusal surface and poured with epoxy resins. The dies were evaluated and it was noted that dimensional accuracy, compatibility and detail reproducibility was excellent when polyether and addition silicon was used.[5]

To determine the dimensional accuracy of dies made using a combination of four impressions materials and 3 type IV die stones. A metal die was prepared for a molar complete cast crown and its replicas were made with type IV die stones. When the dies obtained were analyzed under travelling microscope, they showed that the stone dies exhibited expansion in their size when compared with the molar die [39]

Also in the comparative study done by Philip duke, Keith Moore, Steven P.Haug. compared the properties of 3 new die materials and 2 conventional type IV gypsum products where they have seen the linear dimensional change, detail reproduction, surface hardness, abrasion resistance and transverse strength of 2 recently introduced, resin modified gypsum die material and 2 conventional type IV gypsum die material was studied. The result showed that gypsum products were not significantly superior to the conventional type IV gypsum die material. In general, the epoxy resin exhibited the best properties of the materials in this study, however its setting shrinkage may necessitate alternations in technique to achieve well adapted casting.

In the study, the result obtained from the above tests for dimensional accuracy showed superior results with respect to polyurethane resin die material as compared improved die stone and the least with that of die stone which was due to its greater abrasion resistanceand higher compressive strength.

Various hardness tests are used for determining the hardness of dental materials and the selection of the test was determined by the material being measured. Vickers hardness test was suitable for determining the hardness of brittle materials. Therefore, it has been used for measuring the hardness of the die materials. Where Vickers hardness test was conducted for 20 samples each of die stone, improved die stone and polyurethane resin die material on 10 samples of each group die hardener was applied and remaining without die hardener.

The results obtained from the Vickers hardness test showed that the polyurethane resin die material was better than the die stone and improved die stone because of its greater compressive strength.

CONCLUSION

From the present study, following conclusion can be drawn;

There was no significant difference between mean linear dimension (A) in group of ultra-rock, kalrock and polyurethane resin die material at 2 hours, 24 hours, and 7 days. However, there was significant difference between mean vertical dimension (B) in group of ultra-rock, kalrock and polyurethane resin die material at 2 hours ,24 hours, and 7 days. Again, significant difference was seen between mean vertical dimension (C) in group of ultra-rock, kalrock and polyurethane resin die material at 2hours, 24hours, and 7 days. There was significant difference between mean hardness in group of ultra-rock, kalrock, and polyurethane resin die material after using die hardener. There was significant difference between mean hardness in group of ultra-rock, kalrock, and polyurethane resin die material without using die hardener.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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