THE EFFECT OF STORAGE ON THE DIMENSIONAL CHANGES OF DENTAL STONES

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INTRODUCTION

It is of little value to be aware of the dimensional inaccuracies produced during the casting procedure and methods whereby they may be controlled, if there exists an inherent inaccuracy in the master cast obtained from the mouth.

Accordingly a necessary preliminary investigation essential to the observation of the dimensional changes and other related properties of the materials used in partial denture casting procedure was a study of the dimensional changes which may occur in dental stone under various storage conditions,as it is not uncommon for a period of several days to elapse between pouring the master cast, its duplication, and the production of the metal casting.

The methods which have been used by many investigators (TAYLOR et al, 1930; WORNER, 1942; DOCKING and DONNISON, 1948; FINGER, 1980) to observe the dimensional changes of stone or gypsum materials have been directed more towards obtaining reliable data on the changes in linear dimensions of the materials during the setting process than the possibility of dimensional changes occurring after the final set, that is in conditions of storage. As the final accuracy of a cast partial denture must be controlled to a large extent by any changes occurring in the master cast after pouring, the preliminary study was embarked upon in order to determine the effect of storage conditions on dimensional stability.

STORAGE CONDITIONS

The effect of storage of dental stone and plaster before mixing has been described by many investigators (BUCHANAN and WORNER, 1945; PEYTON and CRAIG, 1971; PHILLIPS, 1973; ANDERSON, 1976; COMBE, 1977) who have shown that those materials are sensitive to changes in the relative humidity of their environment, a dry atmosphere condition being the most desirable method of storage.

However, once the setting reaction has been completed, the dimensions of any cast will be relatively constant thereafter under ordinary conditions of room temperature and humidity (SWEENEY and TAYLOR, 1950; MAHLER, 1955; PHILLIPS, 1973; ANDERSON, 1976). As the stone dries out, however, a slight shrinkage occurs followed by an expansion on wetting again. SWEENEY and TAYLOR (1950), measured the dimensional changes occurring in dental stone when stored in a controlled atmosphere approximating summer laboratory conditions (25°C, 63% relative humidity), and their results indicated that the maximum contraction was obtained after 9 - 14 days of storage, being nearly constant after 21 days. These dimensional changes were so minimal, however, that they did not appear to be of practical significance (average value of 0.019% after 25 - 36 days of storage).

MATERIALS AND METHODS

Casts were made by pouring stone into preformed wax moulds. Five posts made from stainless steel wire were attached at the base of the moulds. Each post was 5 mm long and in order to prevent rotational movement, a small flat was ground on the embedded side of each wire. The resultant casts were 20 mm in thickness and the posts were positioned as shown in Figure 1.

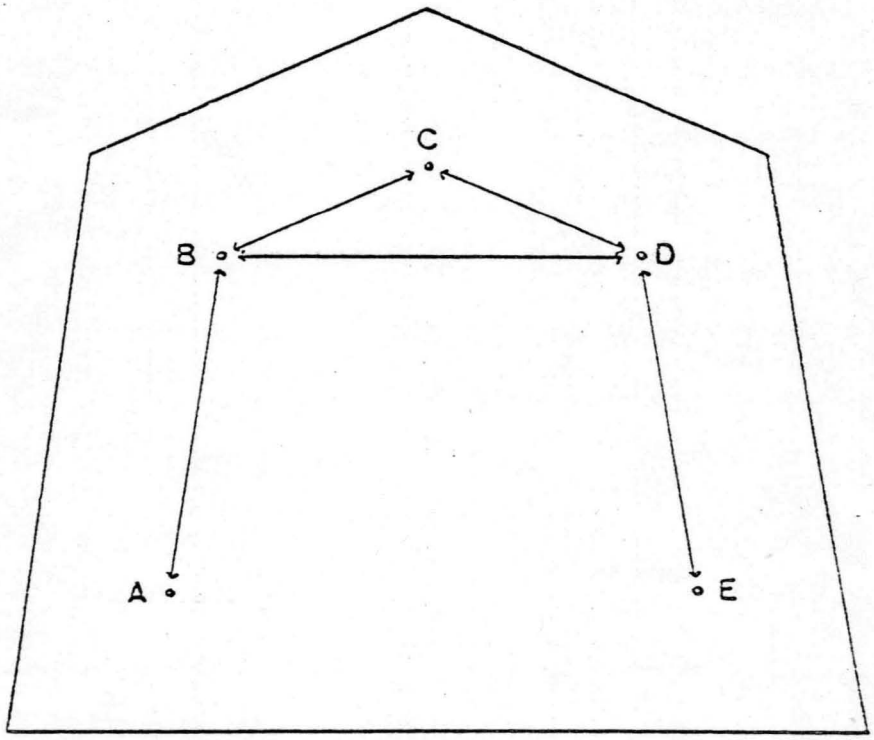

Figure 1. The position of the posts in the stone cast.

A mix of 100 gm of dental stone* and 30 ml. of tap water was prepared. Mixing was done by hand spatulation over a period of one minute at an approximate rate of 180 strokes/minute. The mix was then vibrated into the mould. Three casts were made individually. In all cases the mixes had a homogenous appearance when mixing was completed.

After the final set of the stone which was about one hour after mixing, the casts were removed from the moulds and length measurements between the various posts were obtained at room temperature using a measurescope**

The casts were then stored for 7 days as this was considered the most likely length of storage time under practical laboratory conditions before a casting was produced. The conditions of storage were as follows:

1. One specimen was put on a glass plate and stored in air at room temperature.
2. One specimen was put in a "humidor" which consisted of an airtight plastic container with a glass plate on its base. A sheet of damp napkin was put inside the container in order to provide an artificial atmosphere of 100% relative humidity.
3. One specimen was put in a desiccator containing silica gel to absorb any water vapour.

The length measurements between the posts were repeated every day up to seven days. Each investigation was carried out four times with four different casts. All readings were made at room temperature, approximately 22 $\pm$ 2^{o}C.

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*Kafferata, Carlisle, U.K.

**Nikon Measurescope, Nippon Kogaku K.K. Japan.

RESULTS

The results of the length measurements for each stone cast under its respective condition of storage are presented in Tables 1, 2 and 3. From these figures the linear dimensional changes which occurred between the reference points can be expressed both as length measurement changes and percentage changes. In view of the variability in dimensions of individual stone casts and potential casting designs it was deemed to be of more value to consider the dimensional change in percentage terms.

It is clear that any expansion or contraction within a stone cast will be determined by crystal growth within the set material and will not be restricted in direction. For complete analysis of the data therefore the total changes in all areas were summated and an overall percentage mean obtained for casts stored in each of the three conditions. These mean values are presented in Figure 3 and from this it is clear that the greatest dimensional change occurs within the first 24 hours after which it remains relatively constant and independent of the storage time up to a period of 7 days.

DISCUSSION

From the results presented it is clear that stone casts do not remain dimensionally stable following their final set. Casts which are stored in a humid environment tend to show an overall expansion of approximately 0.02% over 7 days whereas casts which are stored in either atmospheric conditions or absolutely dry conditions show an overall contraction of approximately 0.02%. It is apparent however, that this dimensional change is evident in the first 24 hours of storage, following which the cast remains dimensionally stable within the

Table 1 Length measurements (mm) between selected points in stone models stored under atmospheric conditions for 7 days

Specimen	Measure-ments	Initial	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day
J	A - B	20.16	20.16	20.155	20.16	20.155	20.155	20.16	20.16
	B - C	15.63	15.62	15.63	15.625	15.625	15.63	15.625	15.63
	C - D	14.64	14.635	14.63	14.635	14.64	14.64	14.635	14.64
	D - E	21.86	21.86	21.86	21.855	21.86	21.855	21.85	21.86
	B - D	25.14	25.14	25.135	25.14	25.13	25.14	25.14	25.13
K	A - B	18.74	18.74	18.74	18.74	18.735	18.735	18.74	18.73
	B - C	16.21	16.205	16.21	16.205	16.21	16.205	16.205	16.21
	C - D	15.62	15.615	15.615	15.62	15.62	15.62	15.615	15.615
	D - E	20.91	20.91	20.91	20.905	20.91	20.90	20.905	20.91
	B - D	23.55	23.55	23.54	23.55	23.545	23.55	23.55	23.545
L	A - B	19.64	19.64	19.64	19.64	19.635	19.63	19.64	19.63
	B - C	15.91	15.905	15.91	15.905	15.905	15.91	15.905	15.91
	C - D	16.72	16.715	16.715	16.72	16.72	16.72	16.715	16.715
	D - E	21.18	21.18	21.18	21.175	21.18	21.17	21.175	21.18
	B - D	24.51	24.51	24.51	24.51	24.505	24.505	24.51	24.50
M	A - B	20.47	20.47	20.47	20.47	20.465	20.465	20.47	20.46
	B - C	16.81	16.805	16.81	16.805	16.805	16.81	16.805	16.81
	C - D	15.34	15.335	15.33	15.335	15.34	15.34	15.335	15.34
	D - E	19.28	19.28	19.28	19.275	19.28	19.27	19.275	19.28
	B - D	24.31	24.31	24.305	24.31	24.305	24.31	24.31	24.30

Table 2 Length measurements (mm) between selected points in stone models stored in a humidor for 7 days

Specimen	Measure-ments	Initial	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day
B	A - B	21.26	21.27	21.26	21.26	21.26	21.26	21.265	21.265
	B - C	13.73	13.73	13.735	13.735	13.735	13.735	13.73	13.73
	C - D	13.54	13.545	13.54	13.54	13.54	13.54	13.545	13.545
	D - E	20.90	20.90	20.905	20.91	20.91	20.90	20.90	20.90
	B - D	25.18	25.185	25.185	25.18	25.18	25.185	25.185	25.18
D	A - B	18.23	18.23	18.235	18.24	18.235	18.23	18.23	18.23
	B - C	10.40	10.405	10.40	10.405	10.40	10.40	10.405	10.405
	C - D	10.00	10.00	10.005	10.005	10.00	10.005	10.00	10.005
	D - E	22.18	22.19	22.18	22.18	22.18	22.185	22.185	22.18
	B - D	22.18	22.18	22.18	22.18	22.185	22.19	22.18	22.185
F	A - B	18.89	18.895	18.89	18.89	18.89	18.89	18.90	18.895
	B - C	13.96	13.96	13.96	13.965	13.965	13.965	13.96	13.96
	C - D	14.00	14.01	14.00	14.00	14.00	14.00	14.005	14.005
	D - E	18.56	18.56	18.57	18.57	18.565	18.56	18.56	18.56
	B - D	23.20	23.205	23.20	23.205	23.20	23.21	23.20	23.20
H	A - B	18.97	18.97	18.98	18.98	18.98	18.97	18.97	18.97
	B - C	15.12	15.125	15.12	15.125	15.12	15.12	15.125	15.125
	C - D	13.99	13.99	13.995	13.995	13.99	13.995	13.99	13.995
	D - E	18.92	18.925	18.92	18.92	18.92	18.93	18.925	18.92
	B - D	24.56	24.56	24.56	24.56	24.57	24.57	24.56	24.57

Table 3 Length measurements (mm) between selected points in stone models stored in a desiccator for 7 days

Specimen	Measure-ments	Initial	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day
A	A - B	13.54	13.54	13.535	13.535	13.535	13.54	13.54	13.54
	B - C	12.39	12.385	12.39	12.39	12.39	12.385	12.385	12.385
	C - D	12.71	12.71	12.71	12.71	12.705	12.70	12.71	12.705
	D - E	13.58	13.575	13.58	13.575	13.58	13.58	13.575	13.58
	B - D	19.80	19.80	19.795	19.80	19.80	19.795	19.80	19.795
C	A - B	15.27	15.26	15.27	15.265	15.265	15.27	15.27	15.27
	B - C	12.02	12.02	12.015	12.02	12.02	12.015	12.015	12.015
	C - D	11.56	11.56	11.56	11.56	11.555	11.56	11.555	11.555
	D - E	17.34	17.34	17.335	17.33	17.335	17.34	17.34	17.34
	B - D	22.26	22.255	22.255	22.26	22.26	22.25	22.26	22.26
E	A - B	19.14	19.135	19.14	19.135	19.135	19.14	19.14	19.14
	B - C	15.32	15.32	19.31	19.32	19.32	19.315	19.315	19.315
	C - D	13.94	13.94	13.94	13.94	13.93	13.94	13.935	13.935
	D - E	19.35	19.35	19.345	19.345	19.35	19.345	19.35	19.35
	B - D	23.03	23.025	23.02	23.03	23.03	23.03	23.025	23.03
G	A - B	19.32	19.31	19.32	19.31	19.31	19.32	19.32	19.32
	B - C	14.03	14.03	14.025	14.025	14.03	14.025	14.025	14.025
	C - D	12.86	12.855	12.86	12.86	12.855	12.86	12.85	12.85
	D - E	18.55	18.55	18.545	18.54	18.545	18.55	18.55	18.55
	B - D	23.01	23.00	23.00	23.01	23.01	22.995	23.01	23.01

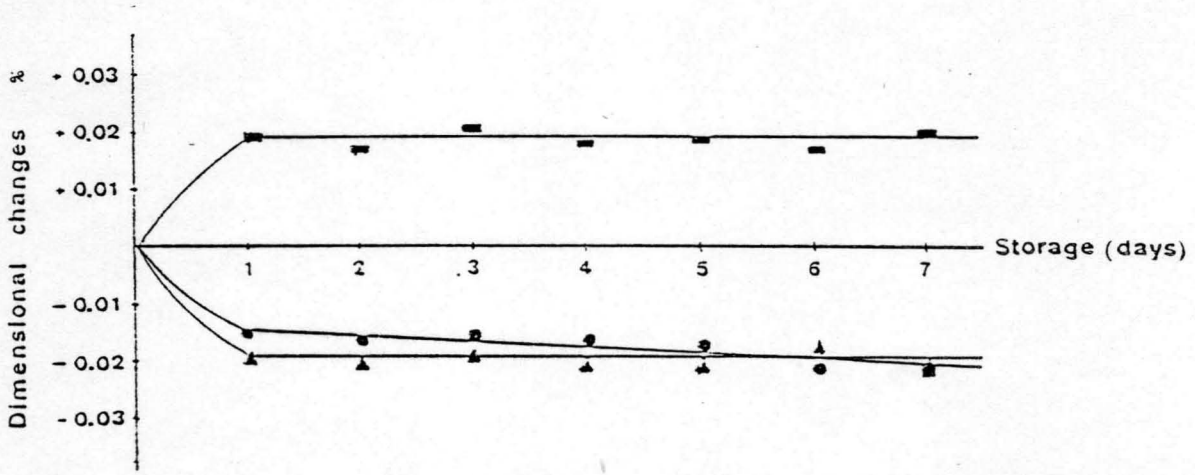

Figure 3. The mean percentage expansion and contraction occurring over a period of seven days of stone casts in various conditions of storage:

- ▬ in humidor
- ▲ in desiccator
- ● in open atmosphere

chosen environment. It could be postulated that for casts stored in the humidor that the expansion is due to the uptake of water to bring the cast into equilibrium with its environment. Conversely the contraction which takes place in atmosphere or desiccator storage may be due to evaporation of water after the final set, being slightly less in the atmosphere (with a higher relative humidity) than in the desiccator.

In practical purposes the dimensional changes in the stone after the first day of storage are therefore at a maximum 0.02%. Translated into mesurement terms this would represent a linear error of only 0.004 mm in a 20 mm length of cast, an error which is not considered to be of practical importance. Also the difference between maximum contraction and maximum expansion would be only 0.008 mm in a 20 mm length.

CONCLUSIONS

Although dimensional changes do occur in dental casts which have been stored for even relatively short periods of time, these changes are not considered to be of practical significance in the effect that they might have on the resultant accuracy of a denture casting. Provided that the stone cast produced from the impression is an accurate replica of the patient's mouth any subsequent dimensional inaccuracy must occur at a later stage in the procedures in the production of a casting.

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