NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT		NBS REPORT
0708-20-3824	December 31, 1959	6327

Progress Report

A METHOD OF EVALUATING THE CLINICAL EFFECT OF WARPING A DENTURE: A CASE REPORT

by

Julian B. Woelfel*
George C. Paffenbarger**

* Research Associate, Research Division of the American Dental Association, Dental Research Section, National Bureau of Standards, on leave from the Faculty of the College of Dentistry, the Ohio State University, Columbus, Ohio.
** Senior Research Associate, Research Division of the American Dental Association, Dental Research Section, National Bureau of Standards.

This work is a part of the dental research program conducted at the National Bureau of Standards in cooperation with the Council on Dental Research of the American Dental Association, the Army Dental Corps, the Dental Sciences Division of the School of Aviation Medicine, USAF, the Navy Dental Corps, and the Veterans Administration.

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

A METHOD OF EVALUATING THE CLINICAL EFFECT OF WARPING A DENTURE: A CASE REPORT*

Abstract

A complete upper artificial denture, having a cross-linked acrylic resin base, was warped by boiling water. This treatment resulted in a shrinkage of 0.4 mm across the posterior of the denture without seriously affecting its fit and serviceability. Additional warpage induced by heating the denture, encased in gypsum, in boiling water caused an additional shrinkage of 0.5 mm across the posterior. The denture could still be worn, but its fit was affected adversely. The relationship was good between the fit of the denture on a gypsum cast of its tissue-bearing surface and changes in dimension of the denture. Both of the foregoing correlated well with the patterns given by coating a pressure-indicating paste on the tissue bearing surface of the denture.

1. INTRODUCTION

This report demonstrates how great a dimensional change can occur across the posterior section of an upper artificial denture without seriously affecting the fit or the functioning

* This investigation was supported in part by a Research Grant D-605 to the American Dental Association from the National Institute for Dental Research, Public Health Service.

of the denture. This is a preliminary report and gives the data on one patient only. However, it is presented at this time to outline a procedure that other investigators can use.

The most critical conditions were selected to magnify any adverse developments in the fit of the denture. The patient was 73 years old and was very lean. He had worn dentures for 17 years. Although the ridges were well healed, the mucosa covering them was very thin with a minimal amount of soft tissue cushion between the outer mucosa and the bone. The arch was wide, large and steep. All of these conditions would aggravate the effect of dimensional change on the fit and function of the denture.

2. PREVIOUS WORK ON CHANGES IN DIMENSION OF CLINICAL DENTURES

A clinical upper artificial denture with a phenol-formaldehyde resin base which shrank approximately three-fourths of a millimeter across the molar-to-molar dimension in about 20 months was described in a previous publication [1]. This shrinkage occurred gradually and did not affect the fit, function or comfort of the denture. The patient has worn this denture for almost 20 years. No data are available beyond 27 months because

the reference lines wore off. Similar technic dentures having a phenol-formaldehyde resin base continued to shrink after they were processed. These changes were checked qualitatively by making an artificial stone cast of the tissue-bearing surface of the artificial denture after receiving it from the laboratory. If the denture did not reseat on the cast, some dimensional changes had taken place. Photographs showing such changes have been published previously [2].

Several years ago the National Bureau of Standards and the dental service of the Veteran's Administration cooperated in a study of the dimensional stability of clinical dentures made with heat-curing and self-curing acrylic resin bases [3]. After six years the greatest change found was three-fourths of a millimeter (molar-to-molar and flange-to-flange) in a lower artificial denture made with a self-curing acrylic resin base. The patient was unaware of any dimensional change in the denture.

All of the foregoing changes in dimension occurred slowly. Therefore, the tissues could easily adapt to the gradual changes without the patient realizing that any change was taking place.

3. GENERAL PATTERN OF THE EXPERIMENT

The following experiment was designed to cause comparatively large dimensional changes rapidly in order to determine the amount

of dimensional change that could be detected clinically, where the changes were manifested, and what their effects were.

Complete upper and lower dentures were processed from a cross-linked, powder-liquid acrylic resin, in November 1957 for a thin male patient 73 years old. He wore these dentures, which were satisfactory in all respects, until June 1958, when a new complete upper denture of the same material was fabricated.

This second denture was made in order to improve esthetics, to determine the dimensional changes of a thicker denture of the same shape and material, and to serve as a replacement for the original upper denture which was to be warped experimentally. Both upper dentures were highly satisfactory to the patient as far as function and retention were concerned; but, upon questioning, the patient preferred the thicker denture because he said it "felt more natural." He experienced no difficulty at any time from alternately using the two upper dentures. The new upper denture was worn by the patient from June 12, 1958 to August 18, 1958.

The original denture, which had been worn by the patient for seven months, was stored in water for nine weeks while he wore the new denture. The original denture then was worn by him for two days immediately preceding the warping.

The dimensional changes on the dentures were followed by the technics used by other workers [1 - 4]. Quantitative linear changes over the posterior section of the dentures were followed during processing, during use in the mouth, and after each treatment of the denture. The denture was conditioned

in water at 73 ± 2°F. for thirty minutes before each series of measurements. The dentures were measured at this temperature in order to minimize changes in dimension caused by the high thermal expansion of the resin.

To show gross changes qualitatively, a gypsum cast was poured into the denture before it was warped. The fit of the warped denture on the cast was then compared with the linear changes. The fit of the denture was also checked in the mouth by using a coating of pressure-indicating paste on its tissue-bearing surface.

The denture was first warped by boiling in water for 15 minutes and then cooled rapidly in water at room temperature. The second warping was accomplished by investing the denture in gypsum and then by boiling the invested denture in water for 40 minutes followed by quenching immediately in water at room temperature.

4. DATA

Linear changes over the molar-to-molar and flange-to-flange distances were measured on the original upper and lower dentures. As shown in Figure 1, the molar-to-molar shrinkage (AB) from the wax form to the polished resin denture was approximately 0.7 percent (0.4 mm). A recovery of slightly over 0.2 percent (0.1 mm) occurred during the first three months of use. At this time apparent equilibrium conditions were reached as no significant changes were

noted up to nine months of use. The foregoing changes were so small that they had no detectable effect on the fit and function of the dentures.

Flange-to-flange measurements, where they could be made, were of the same order as the molar-to-molar measurements. Thus the shrinkage and expansion were nearly symmetrical and no significant warpage was taking place.

Step 1. Immediately prior to warpage of the original denture, the undercuts were blocked out with clay and a gypsum cast was poured. The pouring of the gypsum cast caused both the molar-to-molar and flange-to-flange distances to lengthen on the average about 0.12 percent (0.08 mm). The flanges were bent out by the force of the setting expansion of the gypsum about 0.11 mm. At the same time the molar-to-molar portion of the denture was stretched over 0.04 mm. Thus the dimensional changes of the denture induced by the setting expansion of the gypsum caused a slight warpage but the denture on removal from the cast returned almost to its dimensions prior to pouring the cast (Figure 1). The amount of these changes can be explained by the linear unrestricted setting expansion of the gypsum (artificial stone) (0.1 percent). It is surprising that the crystal thrust, or whatever is responsible for the setting expansion, can exert that much force.

Step 2. When the original denture had been in use two days the patient was re-examined. The upper denture exhibited excellent

retention and stability and had been perfectly comfortable. The denture was dried and the entire inner surface was coated with pressure-indicating paste *, spread thinly so the brush marks would show. The denture and the upper ridge were sprayed with an emulsion supplied with the pressure-indicating paste. The denture was inserted firmly and the patient was instructed to simulate chewing for thirty seconds. The border seal was released and the denture was removed carefully. A photograph made of the tissue-bearing surface of the denture shows a relatively even distribution of contact between the denture and the mucosa (Figure 2). The denture also fitted the gypsum cast which had been poured into it (Figure 3).

Step 3. In an attempt to warp the denture, it was placed in hot water (180 - 190°F) for 25 minutes and then quenched in water at 75 ± 5°F. The denture was then conditioned in water at 73 ± 2°F for 30 minutes and tried on the cast. The fit was equally as good as that shown in Figure 3. The molar-to-molar and flange-to-flange measurements were about the same as previously (Figure 1). Very little warpage had been caused by heating the denture in water at 180- 190°F for 25 minutes. Evidently 180 - 190°F was not high enough to release the internal strain.

* P.I.P. Pressure Indicator Paste (Mizzy, Inc.)

Step 4. The denture was given to the patient, who ate his lunch and returned two hours later. During this time the denture was perfectly comfortable and the retention was excellent.

Step 5. The denture was boiled for 15 minutes and then quenched in water at 75 ± 5°F.* Molar-to-molar and flange-to-flange measurements showed a considerable shrinkage (0.94 percent [0.51 mm] and 0.46 percent [0.33 mm], respectively) (Figure 1). The denture would not seat on the original cast (Figure 4). There was no noticeable resistance from the tissues when the denture was inserted after coating with pressure-indicating paste. The patient simulated chewing for 30 seconds. The denture appeared to fit very well. The patient had no pain, but said, "It felt a little bit tight." Photographs of the tissue-bearing surface of the denture show the newly evident pressure areas on the buccal surfaces of the tuberosities (Figure 5).

Step 6. A gypsum cast was poured into this warped denture after the undercuts in the denture were blocked out with clay. Reference to Figure 1 again shows that the denture was expanded on the average about the same amount as previously across the posterior region; when it was removed from the gypsum cast the denture returned to the dimensions it had prior to pouring the cast.

---

* The release of strain in an acrylic resin denture by boiling in water was demonstrated years ago.[5]

Step 7. The denture was returned to the patient at 4:30 p.m. The occlusion and retention were very good. No pain was experienced. The patient said, "If anything, it fits better or somewhat tighter than before."

Step 8. The patient returned at 9:30 a.m. the following day. The denture had been worn until retiring at 11:00 p.m. the night before. He had experienced no difficulty or pain, had been able to eat very well, and said that he had completely forgotten about his teeth during the evening. The denture was coated with the pressure-indicating paste and the patient simulated chewing for 30 seconds. Phtographs (Figure 6) of the tissue-bearing surface of the denture show little of the impingement evident the day previous (Figure 5). Since the denture had not expanded and would seat on the gypsum cast (Step 6), there must have been an accommodating change of the tissues in response to force exerted by the warped denture. Changes of a much greater size than these have been caused in the oral soft tissues by ill-fitting and improperly occluding dentures [6].

Step 9. The denture was boiled in water for 30 minutes and then quenched in water at 75 ± 5°F. The linear measurements showed only negligible changes (Figure 1). The warped denture seated on the gypsum cast which had been poured into it (Step 6). The pattern given by the pressure-indicating paste was the same as just prior to the boiling. Apparently boiling the

denture in water for 15 minutes on the previous day had relieved the strain to such an extent that no additional internal strain was released by the second boiling. It therefore seemed necessary to flask the denture during boiling in order to cause further distortion.

Step 10. A gypsum cast was poured into the denture without blocking out the undercuts. The denture on this cast was then invested in a Hanau upper flask using four separate mixes of gypsum; the porcelain teeth were covered with a double layer of tinfoil 0.001 inch thick to prevent breakage upon deflasking. The flask containing the denture was placed in boiling water for 40 minutes and then cooled immediately in water at 75 ± 5°F for 15 minutes. The denture was deflasked but left on the cast. There was a slight space between the posterior palatal edge of the denture and the cast (Figure 7).

The linear dimensions across the posterior showed no appreciable change on the flange-to-flange distance and 0.09 percent (0.05 mm) shrinkage (Figure 1) as long as the denture remained on the cast. This molar-to-molar shrinkage is evidence of the internal strain placed in the denture by boiling it in water when flasked. As soon as the denture was removed from the cast the flange-to-flange measurement shortened over 0.8 percent (0.6 mm) and the molar-to-molar measurement shortened 0.7 percent (0.4 mm). These changes were anticipated since resin with a high coefficient of thermal expansion

($45 \times 10^{-6}/°F$) was rapidly heated and cooled in a gypsum mold having a low coefficient ($11 \times 10^{-6}/°F$). The incorporation of internal strain in dentures subjected to heating and cooling when incased in gypsum has been demonstrated previously [7, 8].

Step 11. When first inserted, the denture casued slight pain to the patient. It did not rock and caused no pain when completely seated. The patient simulated chewing for 30 seconds. Photographs (Figure 8) of the tissue-bearing surface of the denture with the paste lining again show large pressure areas on the lateral sides of the right and left tuberosities. The denture, when mounted on the original cast, showed a space approximately 2 1/2 mm wide between the posterior palatal edges of the denture and the cast (Figure 9).

Step 12. The denture was returned to the patient at 4:00 p.m. with no adjustment. The denture had good retention, did not rock and caused no pain to the patient. He said, "It just has a tight feeling." The patient returned at 9:30 a.m. the next morning. He said that he would be glad to get the denture out this time. He noticed no loss of retention, and experienced no difficulty in eating with it. He had left the denture in until retiring at 11:00 p.m. and had worn it for three hours the next morning, including breakfast. The patient said, "If anything, the denture fits better than before, other than for a dull soreness, which is only on the right side."

Examination of the upper and lower arches revealed that the only inflammation was on the greatest convexity of the upper right tuberosity. The denture was then inserted after coating with the pressure-indicating paste, and the patient simulated chewing for 30 seconds. Photographs (Figure 10) of the tissue-bearing surface of the denture again (as under Step 8) show a decrease in the size of the pressure areas on the lateral sides of the right and left tuberosities when compared to the previous day (Figure 8). These contact areas in the tuberosity region of the denture were relieved by removing a thin layer of resin. The denture then felt perfectly comfortable to the patient, but did not seem to fit quite as well to the dentist. However, it did not show a tendency to fall down.

Step 13. The denture was measured 24 hours after warping and showed a shrinkage of 0.05 percent (0.03 mm) across the molars and an expansion of 0.09 percent (0.06 mm) across the buccal flanges since the previous afternoon (Figure 1). These small changes may have been caused by the release of some of the strain. The lower denture was measured at this time to determine whether the rather severe warpage of the upper denture had caused any changes in dimension in the lower denture. There was no significant change found in the lower denture, which had been measured eleven days previously (Figure 1).

Step 14. The new upper denture was returned to the patient at this time. It did not press on the uncomfortable upper right tuberosity, nor did it lack retention.

Step 15. The original denture showed a slight recovery in dimension (Figure 1) after five days storage in water at 73 ± 2°F.

Step 16. When the warped denture was tried in the mouth a week after the new denture had been worn, the warped denture did not appear to fit nearly as well as formerly. It had a tendency to fall down and rocked slightly.

Step 17. Additional measurements of the original upper denture, kept in water at 73 ± 2°F for 11 weeks, showed no significant dimensional changes.

5. SUMMARY AND CONCLUSIONS

1. Linear changes were measured across the posterior portions of one clinical set of complete upper and lower dentures during processing, during nine months of service, and after inducing warpage in the upper denture. The denture base was a cross-linked acrylic resin of the powder-liquid type.

2. The molar-to-molar shrinkage from the wax to the polished resin denture was less than 0.4 mm. A recovery of slightly over 0.1 mm occurred during the first three months' use. At this time apparent equilibrium conditions were reached as no significant changes were noted up to nine months of use. These changes were so small that they had no detectable effect on the fit and function of the dentures.

3. Flange-to-flange measurements, where they could be made, were of the same order as the molar-to-molar measurements. Thus the shrinkage was nearly symmetrical and no large warpage was taking place.

4. When a gypsum cast was poured into the upper denture, both the molar-to-molar and the flange-to-flange distances increased about the same amount as the unrestricted setting expansion of the gypsum. When the denture was removed from the cast, almost complete recovery occurred to the dimensions of the denture prior to pouring the cast. Thus no appreciable permanent distortion occurred when a cast was poured in the denture.

5. No internal strain was apparently released when an upper denture made of a cross-linked acrylic resin of the power-liquid type was heated to 180 - 190°F for 30 minutes.

6. Boiling the denture for 15 minutes in water caused warpage which was manifested by shrinkages of 0.51 mm from molar to molar and 0.33 mm from flange to flange. The denture would not seat on the gypsum cast that it fitted formerly.

7. This warped denture was serviceable and comfortable. Evidence of heavy contact of the denture on the buccal surfaces of the tuberosities was evidenced by the pattern of a pressure-indicating paste coating placed on the tissue-bearing surface of the denture. A similar pattern taken the next day showed

considerable reduction of the areas in heavy contact. Since the denture had not changed in dimension, the tissues made an accommodating change.

8. No further warpage was caused when the denture was reboiled in water for 30 minutes. Apparently the boiling of the denture for 15 minutes on the previous day had annealed it to such an extent that no additional internal strain was relieved by the second boiling.

9. Further warpage of the denture was obtained on boiling the flasked (gypsum invested) denture in water for 40 minutes followed by cooling rapidly in water at room temperature. The warpage was manifested by a shrinkage of 0.4 mm on the molar-to-molar distance and 0.6 mm on the flange-to-flange distance. This made the total induced shrinkage across the posterior section of the denture approximately 0.9 mm on the average.

10. The additional warpage caused by boiling the flasked denture caused some slight pain when the denture was inserted, but no pain after it was seated. Larger areas of impingement on the lateral sides of the tuberosities showed up in the pattern of the pressure-indicating paste coating. The denture felt uncomfortable after wearing for several hours, but again the lateral pressure areas on the tuberosities had diminished in size from the previous day. When these areas of impingement were relieved, the denture felt comfortable and did not have a tendency to fall down. However, when the warped denture, which had been kept in water while the

new denture was being worn, was reinserted after a week it had very poor retention.

11. Shrinkages up to 0.5 mm across the posterior section of a complete upper denture did not cause serious misfit and discomfort. When the shrinkage was increased to 0.9 mm the denture did not fit properly.

12. Dimensional changes occurring in the processing of resin dentures are usually of a much smaller order than the induced shrinkage of the upper denture used in this experiment and probably have less clinical significance than many dentists have indicated.

13. The fit of a denture on a gypsum cast that had been poured into the denture, indicated qualitatively the shrinkage that the denture underwent after the cast was poured.

14. A film of pressure-indicating paste on the tissue-bearing surface of a denture to detect areas of hard contact between the denture and the mucosa showed the position of change in dimension that occurred in a complete upper denture.

6. REFERENCES

1. Sweeney, W. T.; Paffenbarger,George C.; and Beall, John R. Acrylic resin for dentures. J.A.D.A. 29:7 Jan. 1942.

2. Souder, Wilmer; and Paffenbarger, George C. Physical properties of dental materials. Circular C 433, National Bureau of Standards, Government Printing Office, Washington 25, D. C. 1942.

3. Mowery, W. E.; Burns, Claire; Dickson, George; and Sweeney, W. T. Dimensional stability of denture base resins. J.A.D.A. 58:345 Sept. 1958.

4. Grunewald, A. H.; Paffenbarger, George C.; and Dickson, George. The effect of molding processes on some properties of denture resins. J.A.D.A. 44:269 March 1952.

5. Taylor, P. B. Acrylic resins: their manipulation. J.A.D.A. 28:373 March 1941.

6. Lytle, Robert B. The management of abused oral tissues in complete denture construction. J. Pros. Dent. 7:27 Jan. 1957.

7. Tuckfield, W. J.; Worner, Howard K.; and Guerin, B. D. Acrylic resins in dentistry. Part II. Their use for denture construction. Austral. J. Dent. 47:1 March 1943.

8. Dimensional changes after recures - Test No. 1. The Vernonite Work Bench, Vol. 6, Feb. 1947.

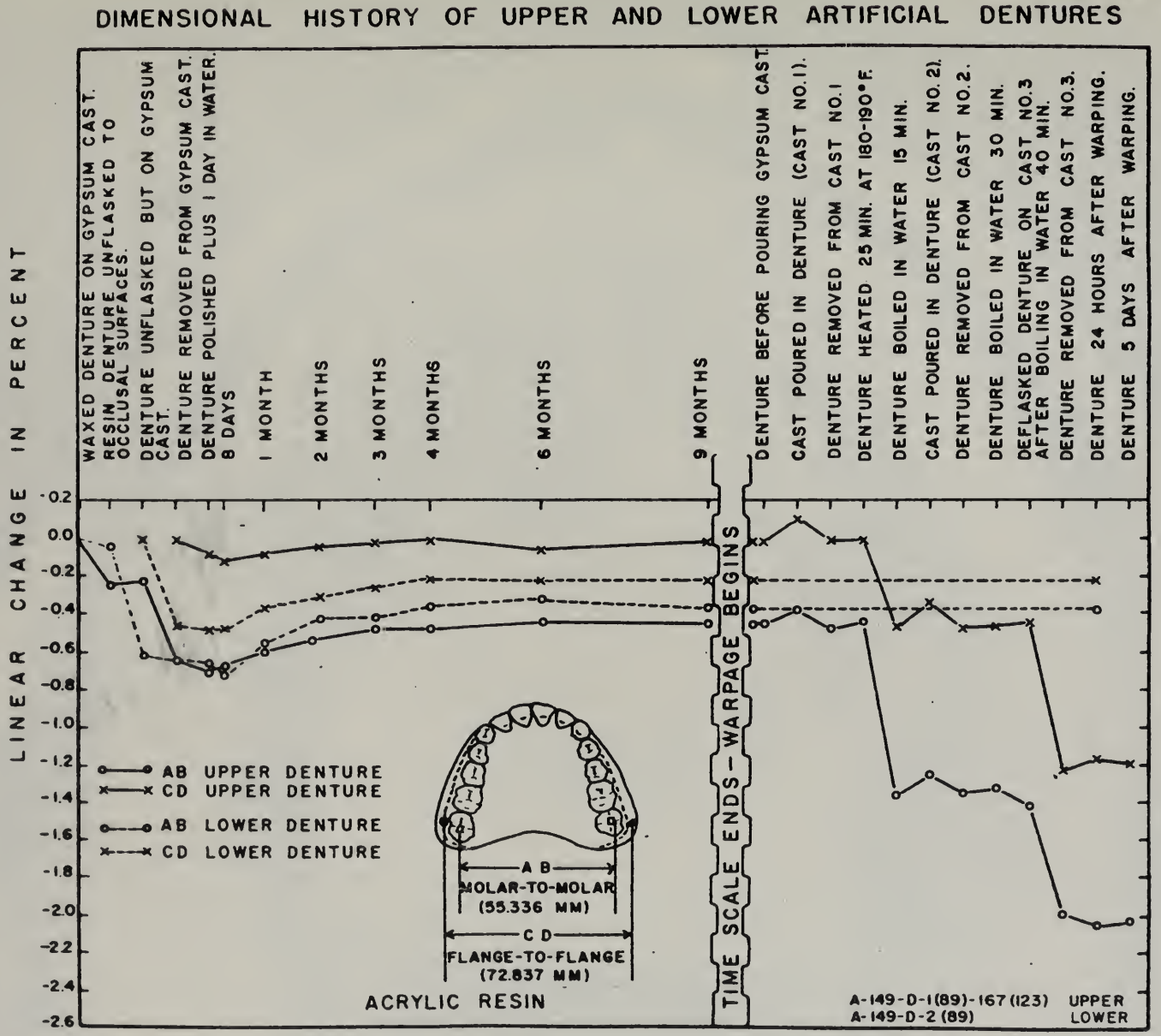

Figure 1. The linear changes occurring on the molar-to-molar (AB) the flange-to-flange (CD) distances of complete upper and lower artificial dentures with a cross-linked acrylic resin base of the powder-liquid type. The changes include those caused by the processing, by sorption of water, by pouring gypsum casts, by heating the upper denture in boiling water for 15 minutes and then quenching in water at room temperature (75 ± 5°F), and by heating the gypsum-invested upper denture in boiling water water for 40 minutes and by quenching the flask for 15 minutes in water at 75 ± 5°F.

Figure 2. Pattern of pressure-indicating paste on the tissue-bearing surface of the upper denture before warping. The contact between the tissue-bearing surface of the denture and the tissue is relatively uniform as judged by the continuous coating of the paste.

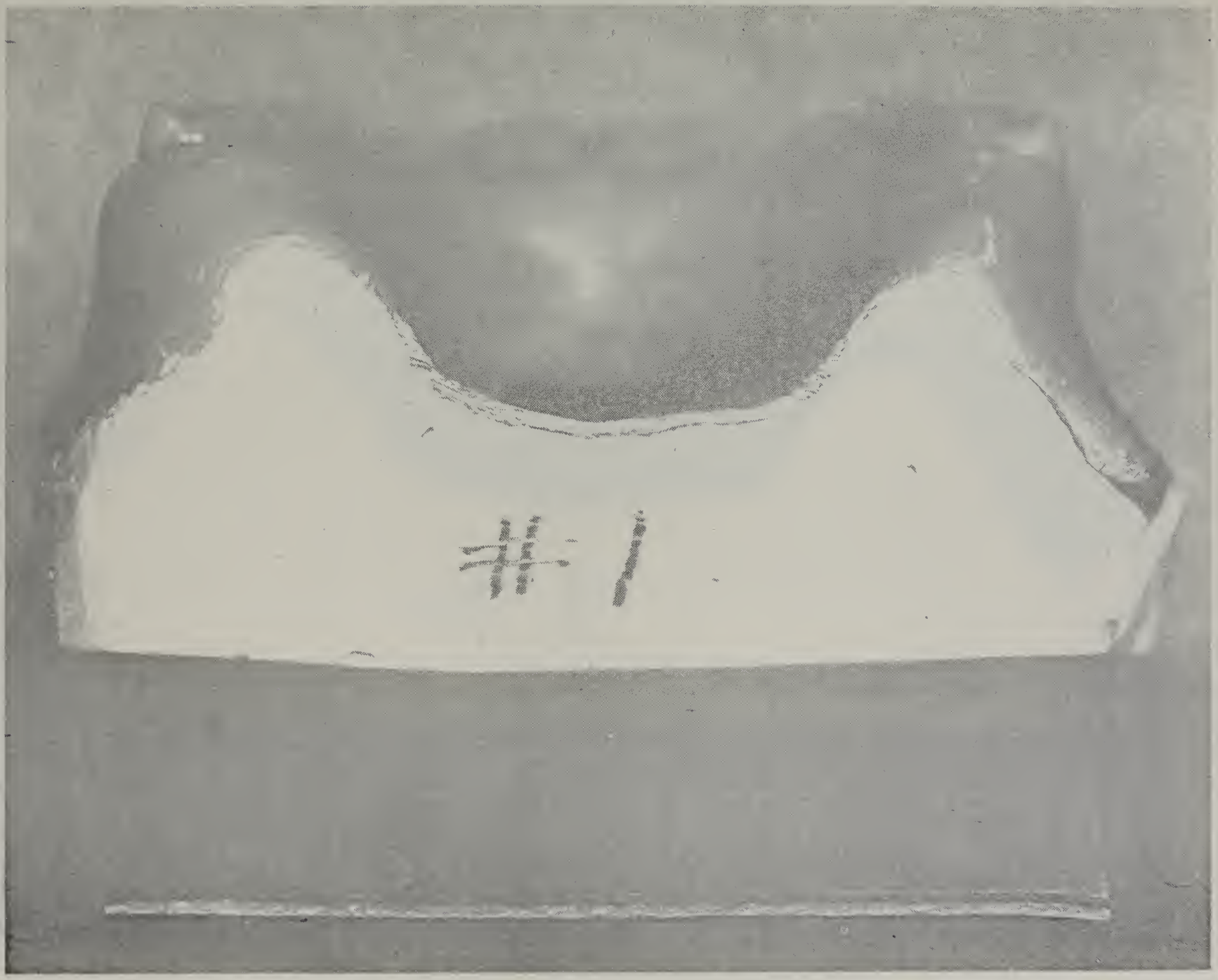

Figure 3. Fit of the denture shown in the drawing in Figure 1 on the gypsum cast which had been poured into it.

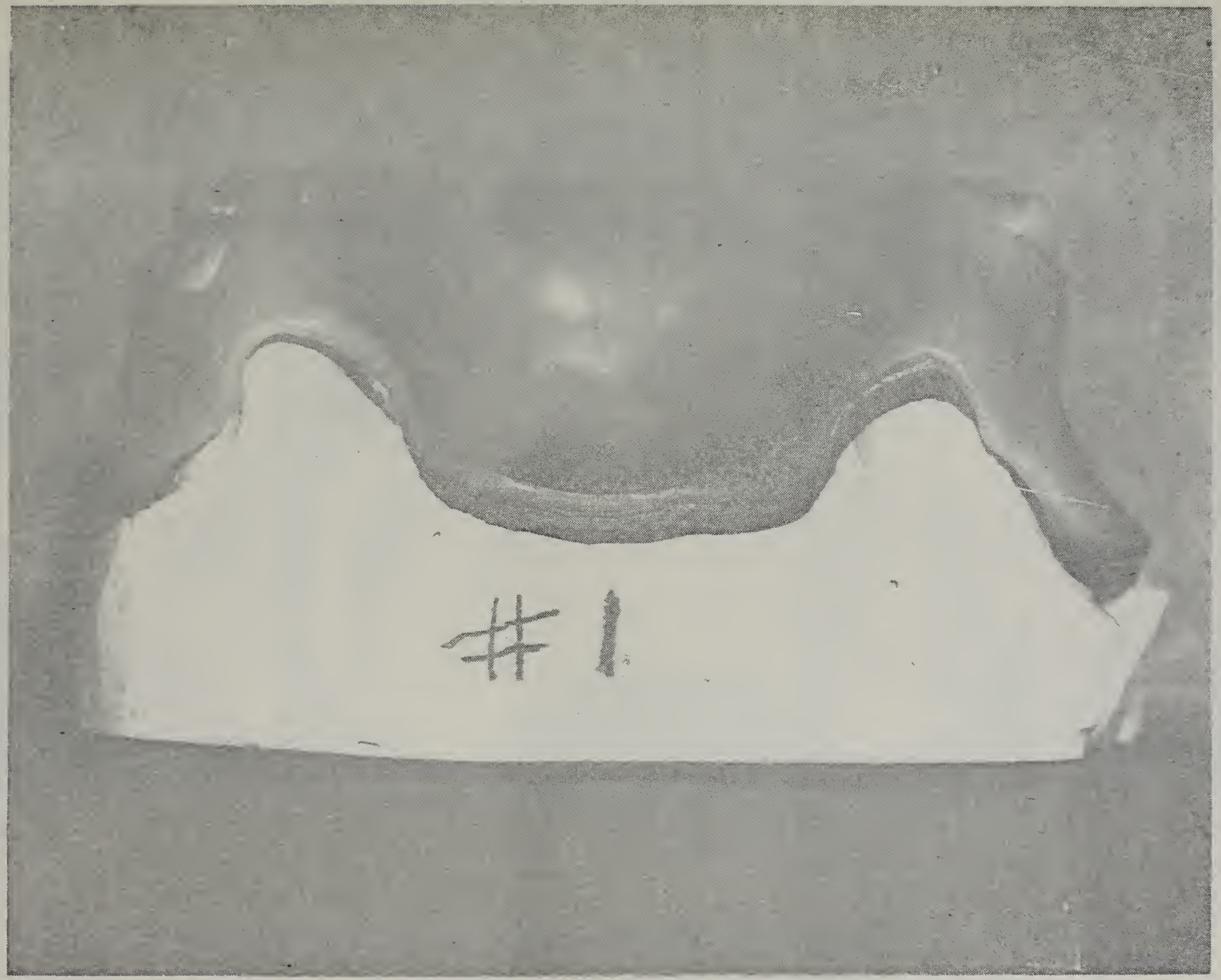

Figure 4. Fit of warped denture on original gypsum cast. Denture was warped by heating in boiling water for 5 minutes followed by quenching in water at room temperature.

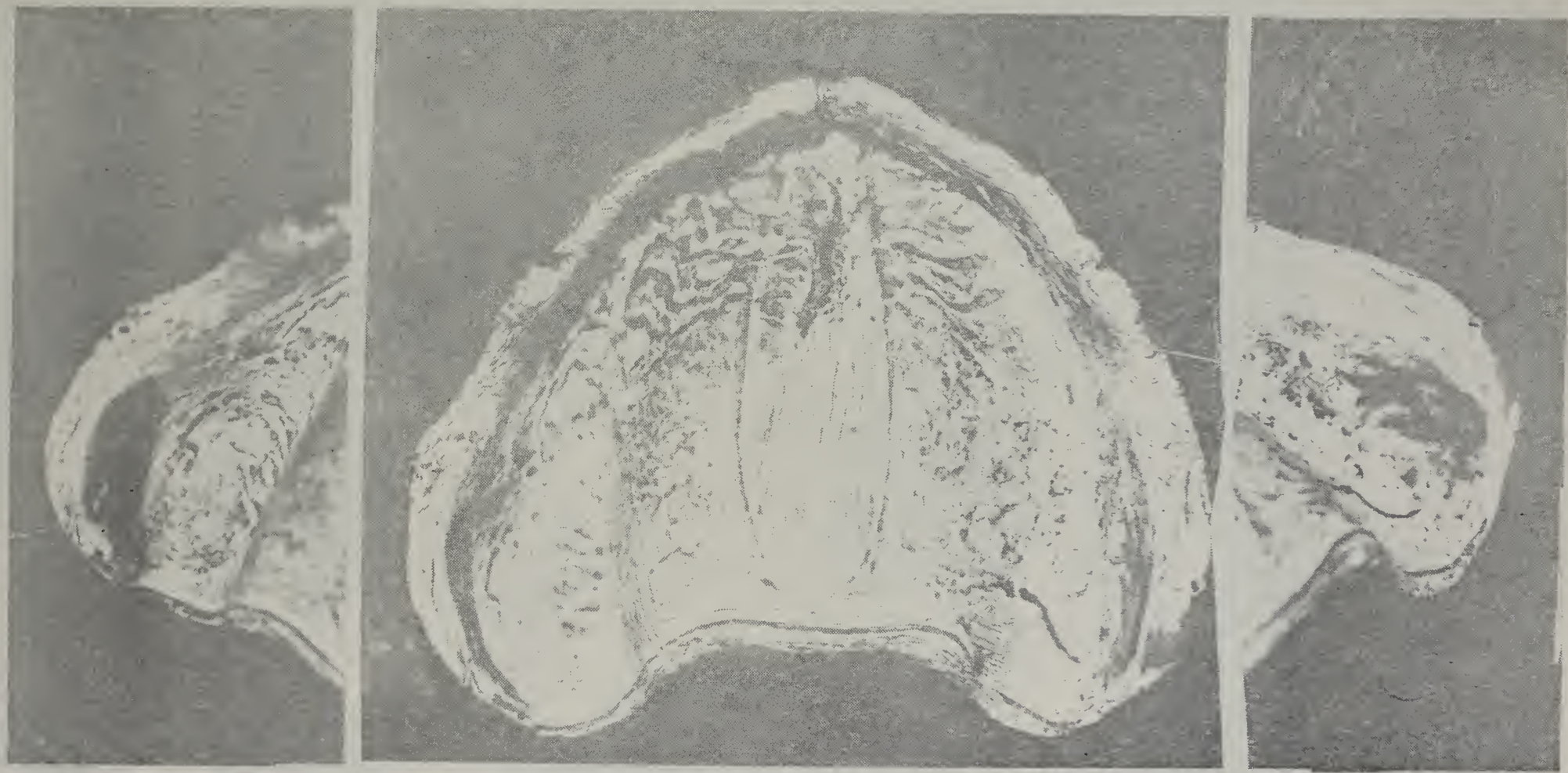

Figure 5. Pattern of pressure-indicating paste on the tissue-bearing surface of the denture warped by boiling water for 15 minutes. Compare central (vertical) view with the pattern shown in Figure 2. Oblique views of the buccal surfaces of the left and right tuberosities are on their respective sides of the vertical view.

Figure 6. Pattern of pressure-indicating paste on the tissue-bearing surface of a denture warped by boiling in water for 15 minutes and then worn for approximately 24 hours. A comparison with the patterns shown in Figure 5 shows that the tissue was receding from the area of hard contact.

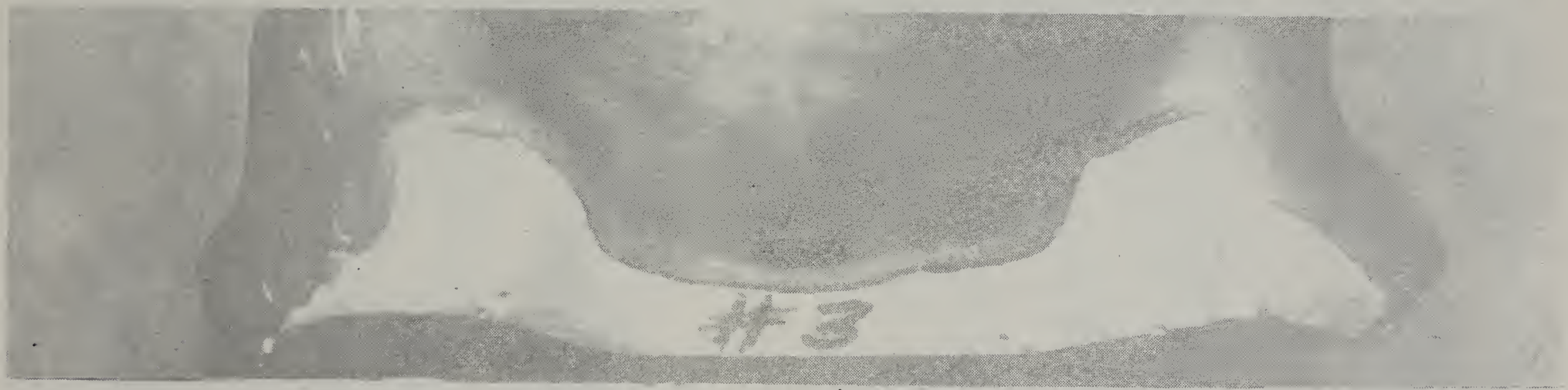

Figure 7. Fit of deflasked denture undisturbed on gypsum cast which was poured into it prior to flasking and boiling in water for 40 minutes. The space between the posterior edge of the denture and the gypsum cast is reflected by the shrinkage of the molar-to-molar distance of 0.09 percent (0.05 mm) (Figure 1) and is evidence of the internal strain placed in the denture by boiling it in water when flasked.

Figure 8. Pattern of pressure-indicating paste on the tissue-bearing surface of a twice-warped denture. Note that the displacement of the film of paste on the lateral sides of the tuberosities is much greater than on the pattern shown in Figure 6.

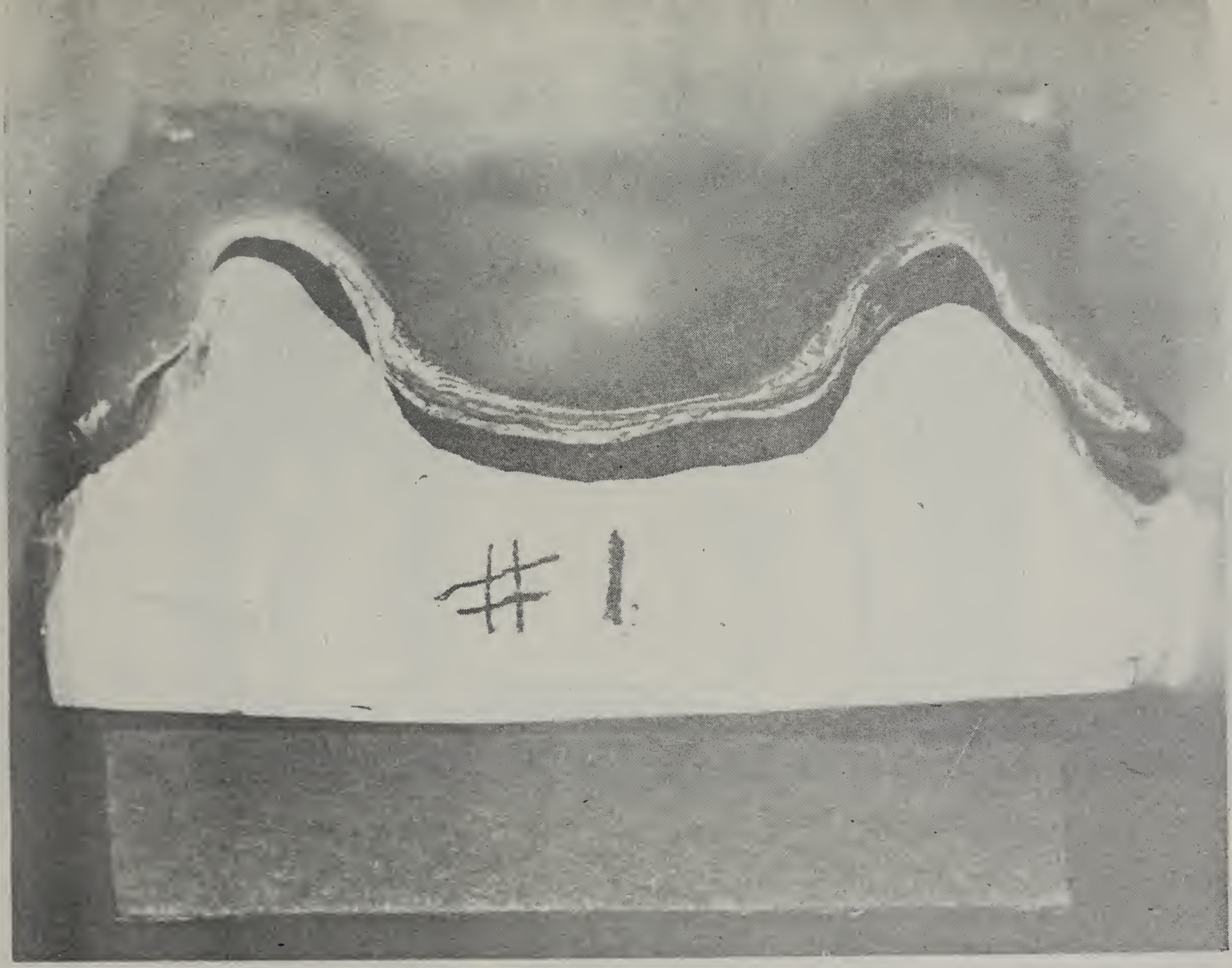

Figure 9. Fit of the twice-warped denture on the original gypsum cast. By comparison of this fit with those shown in Figures 3 and 4 and by reference to the data in Figure 1 the qualitative relationship is clearly seen between the fit of the denture on the gypsum cast and changes in the dimension of the denture.

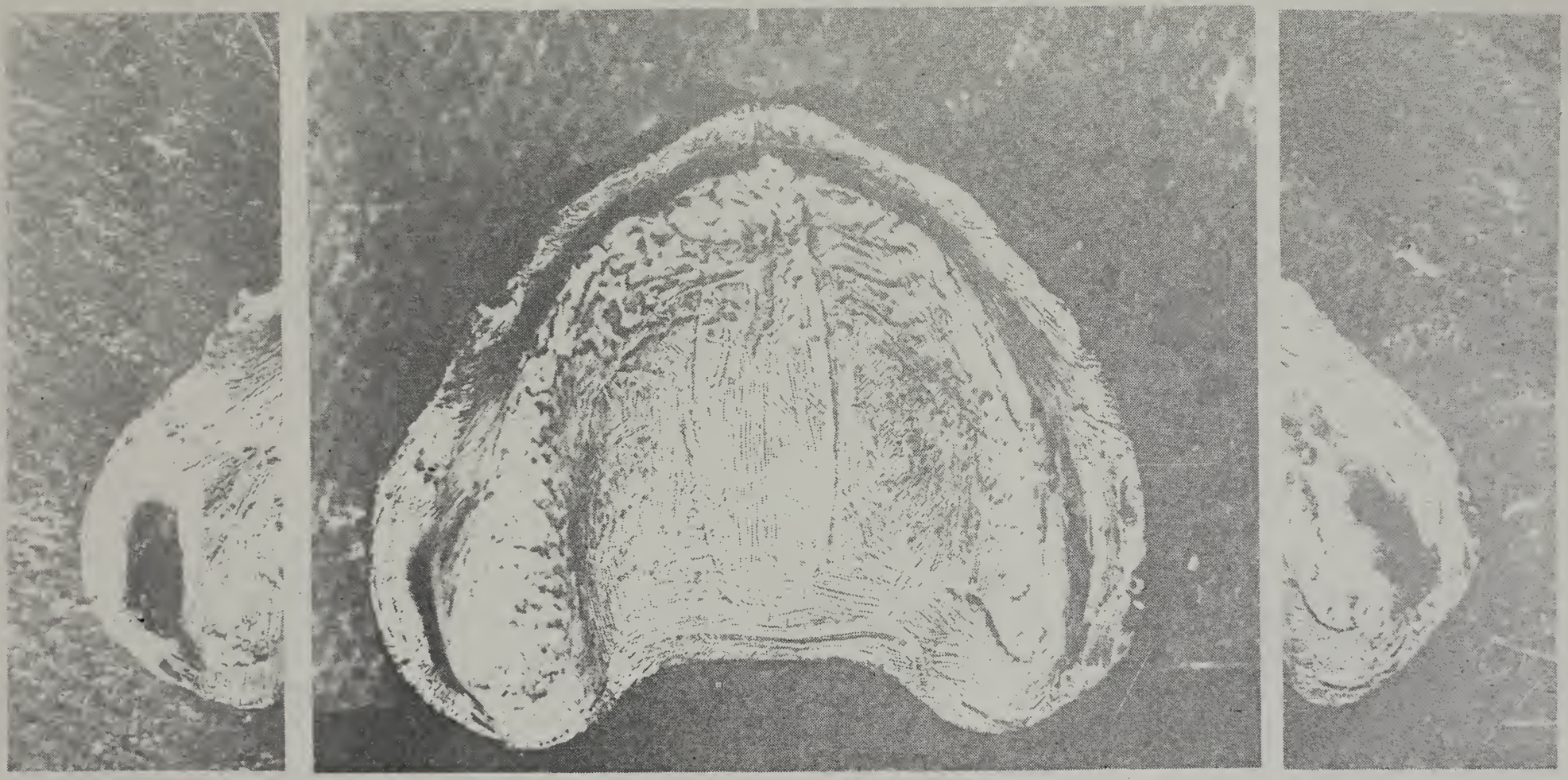

Figure 10. Pattern of pressure-indicating paste on the tissue-bearing surface of a twice-warped denture after it had been worn for approximately 24 hours. A comparison with the pattern shown in Figure 8 shows considerable recession of the tissue where it was in hard contact with the denture.