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# EVALUATION OF THE OCCLUSAL TABLE PATTERN IN REMOVABLE PARTIAL DENTURE WITH UNILATERAL DISTAL EXTENSION SADDLE

BY

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## ABSTRACT

This investigation was undertaken for the purpose of understanding the functional behavior of unilateral extension saddle removable partial dentures and their optimal design, based on clinical experiments. Mainly, the relation between the pattern of the occlusal table and the transmitting lateral force to the abutment tooth was examined. A specially simulated model for the unilateral mandibular extension saddle denture was devised for this purpose. Devices for measuring the tooth mobility and force applicator, and their recording system were used.

Conclusions drawn from this investigation were as follows: (1) An optimal load distribution on the residual ridge under denture saddle was observed when a vertical force was applied on the crest spots of the occlusal table. (2) Reduction of the bucco-lingual width of the occlusal table, particularly in distal area, rationally reduced the lateral transmitting force against the abutment tooth. (3) A lateral force against distal extension saddle had a great effect on the abutment tooth, chiefly on the abutment of indirect retainer. (4) The amount of vertical excursion of distal extension saddle was markedly concerned with the location of loading area when the vertical force was applied on the occlusal table of the denture saddle.

## INTRODUCTION

The functional behavior of distal extension saddle type of removable partial dentures and their appropriate design, based on the experimental and clinical results are incompletely understood. In recent years, the longitudinal prognostic observation have been made on various types of removable partial denture, and also the statistical analysis of their result[1–6]. Experimental investigations on this subject have been reported by the present author[7,8]. In these results, the most important factor that determines the partial denture design seems to be the optimal distribution of the mastica-

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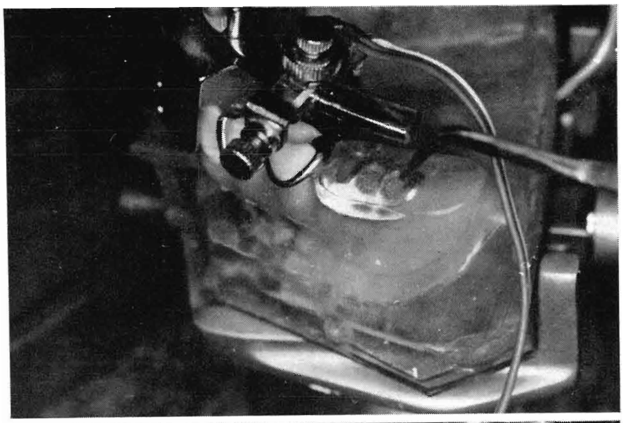
tory force between the abutment and the supporting mucosa. Frechette[9] and Matsumoto[7,8] studied under laboratory condition the effect of partial denture design and load distribution to the abutment teeth. The relationship between loading and mobility of the abutment teeth was affected by the number and location of occlusal rests, the contour and rigidity of connectors, and the extension of the denture bases. These relations were reported by Kaires[10-12] and others[13,14]. However, they did not investigate about the relation between pressure distribution under denture saddle and the pattern of the occlusal table, and related transmitting lateral force to the abutment teeth. For these reasons, the present author has been investigating the optimal distribution of functional load to the mucosa and abutment teeth, particularly the analysis of lateral load in unilateral extension saddle type of removable partial denture both by clinical and experimental observation. These lateral forces were estimated by measuring the amount of the excursion of abutment tooth when the transmitting force was applied to the abutment tooth.

In the extension saddle type of a removable partial denture, the maximal efficiency of the tissue-support should be considered for the preservation of abutment teeth. Kaires[12] showed that the reduction in size of the occlusal table reduced the force acting on the partial denture and lessened stress on the abutment teeth and supporting tissues, but he did not indicate the precise relation of the bucco-lingual width of the occlusal table and its transmitting force, based on the experiments. The author published preliminary reports on these problems but indicated that further experimental evaluation about occlusal table for distal extension type of a removable partial denture is necessary.

In the present investigation, relative excursion of the abutment teeth, and the relative amount of transmitting force to the residual ridge under the denture saddle and to the abutment teeth when a known force was applied on the occlusal table of this type denture were observed. Force distribution to the abutment tooth and residual ridge was analyzed by using a clinically simulated conditions.

## Material and Method

The extension saddle type of removable partial denture was designed to replace the left first and second mandibular molars. The design of this denture was as follows: A circumferential-type clasp for the indirect retainer on the first premolar and Akers clasp for the direct retainer on the second premolar. (Figs. 1 and 2.) This denture framework was cast of a



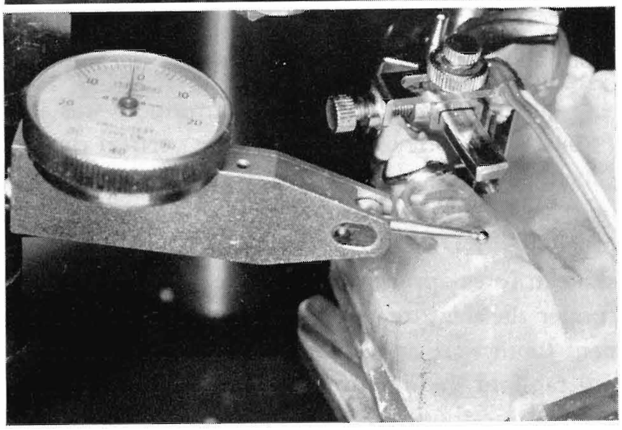


Fig. 1. Extension saddle denture for this investigation on the simulated model with measuring devices.
Fig. 2. Vertical excursion is indicated by a micro-dial gauge on the occlusal table of the saddle.

chromium-cobalt alloy by using the standard laboratory procedures. A simulated model was constructed of clear methyl methacrylate resin and 1.0 to 2.0 mm of silicone rubber (Silastic 390) was relined for the tooth-supporting tissue and residual ridge. This model satisfactorily permitted the physiological mobility of teeth and exhibited the optimal resiliency of the mucosa of residual ridge. The tooth mobility of this simulated model was considerably near the optimal condition for this investigation. Also this resiliency of the soft-tissue precisely followed Sato's[15] and Rehm's[16] data that were measured in clinical intra-oral examination. In this residual ridge, specially devised, small pressure sensitive strain gauge were invested under the artificial silastic mucosa. These located in three different areas, buccal side, crest, and lingual side of the edentulous ridge as shown in

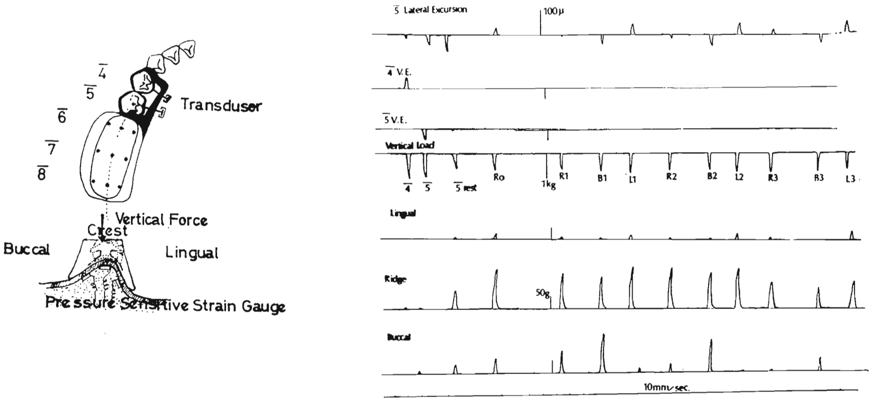



Fig. 3. Pressure distribution under the saddle and lateral excursion of the abutment tooth measured when a vertical force is applied on these nine spots. Chart paper of this recording system is shown.

Figs. 3 and 4. Also the same type of the transducer was invested in the root apex of abutment tooth for recording the vertical distribution of the transmitting loads. The devices for measuring tooth mobility were used for recording the lateral excursion of the abutment tooth by the same method as previously reported[17]. The force applicating transducer was used for the known force application. By the use of these devices, pressure distribution under the denture saddle and the amount of lateral excursion of the abutment tooth were analyzed, while the known forces were applied on the occlusal table of the denture. For giving the vertical forces on the occlusal table, the nine spots were pointed as shown in Fig. 3 and 4. The amount of pressure distribution under the saddle was indicated in $g/_{\pi}mm^2$ and the amount of tooth excursion was expressed in microns. To give a clinical intra-oral conditions, glycerol was given as a salivary coating between the residual ridge of the simulator and the denture saddle.

## Results

1. Application of vertical forces on the occlusal table: The pressure distribution on the residual ridge under the denture saddle was recorded, while 500 g vertical force was applied on the previously decided nine spots of the occlusal table in the extension saddle. These nine spots were located on the occlusal table that was established in the same level as the occlusal plane of the simulated mandibular arch, and this occlusal table had 15 mm bucco-lingual width and the artificial denture tooth area was decided as follows: The first molar area was decided in 5 mm distal area from the distal contour of the second premolar, in 15 mm distal area from the same

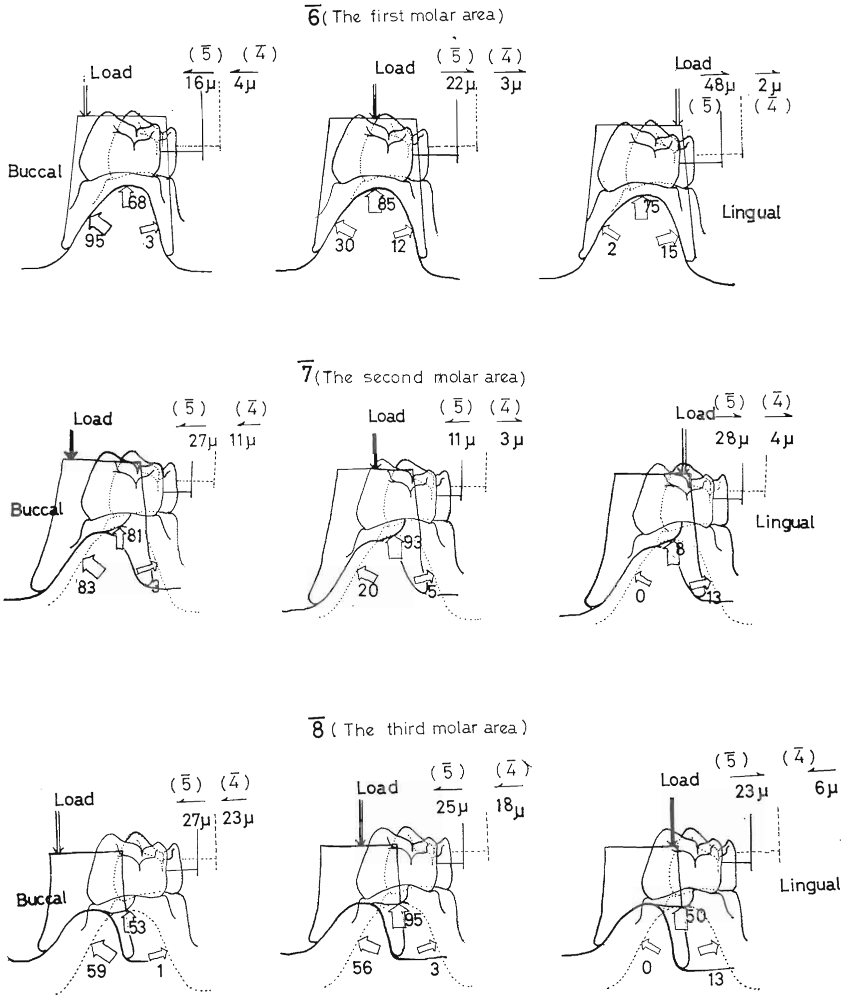



Fig. 4. Pressure distribution under the denture saddle and the amount of lateral excursion, expressed by the mean values.

point as the second molar, and in 25 mm distal area as the third molar. On each tooth area, further three spots were given as follows: The crest spot was on the center of the bucco-lingual width of the occlusal table. The buccal spot was in 5 mm buccal side from the crest spot and the lingual spot was in 5 mm lingual side. 500 g vertical force was applied on each spot by the force applicating transducer. Then the pressure distribution under the saddle and lateral excursion of the abutment tooth were simultaneously recorded on a chart paper. These results are shown in Table 1

Table 1. Pressure distribution under the saddle and lateral excursion of the abutment tooth when a vertical force is applied on nine spots (500 g vertical force) (Mean values and standard deviations, N=9)

| Location of load (500 g vertical load) | Pressure amount under saddle | | | Lateral excursion of abutment | |
|---|---|---|---|---|---|
| | Buccal | Crest (g/$\pi$ mm$^2$) | Lingual | $\overline{4}$ ($\mu$) | $\overline{5}$ |
| **First Molar Area** | | | | | |
| Buccal point of occlusal table of $\overline{6}$ area | 95.1±33.3 | 68.4± 9.5 | 3.3±1.1 | 4.0±1.0 | 15. 9± 4.1 |
| | (139 | : 100 | : 5) | ← | ← |
| Crest 〃 | 29.8±18.3 | 85.5±10.1 | 12.0±5.7 | 2.5±0.0 | 21. 8±13.5 |
| | ( 35 | : 100 | : 14) | → | → |
| Lingual 〃 | 1.5± 0.2 | 75.0±10.2 | 15.0±2.1 | 2.0±0.0 | 48. 2± 4.3 |
| | ( 2 | : 100 | : 20) | → | → |
| **Second Molar Area** | | | | | |
| Buccal point of occlusal table of $\overline{7}$ area | 83.1±30.0 | 81.1± 8.3 | 3.3±0.5 | 10.7±0.0 | 27. 2± 3.8 |
| | (102 | : 100 | : 4) | ← | ← |
| Crest 〃 | 20.3± 7.5 | 93.5±10.7 | 5.4±1.8 | 3.3±0.0 | 11.25± 1.5 |
| | ( 22 | : 100 | : 6) | → | ← |
| Lingual 〃 | 0.0 | 84.5± 1.5 | 13.7±3.7 | 3.6±0.0 | 27. 8± 4.8 |
| | ( 0 | : 100 | : 16) | → | → |
| **Third Molar Area** | | | | | |
| Buccal point of occlusal table of $\overline{8}$ area | 58.5±12.0 | 52.5±10.0 | 9.9±0.0 | 23.3±0.0 | 26. 8± 5.2 |
| | (111 | : 100 | : 2) | ← | ← |
| Crest 〃 | 56.4±71.8 | 95.4±44.5 | 3.2±3.4 | 17.9±0.0 | 25. 0±20.0 |
| | ( 59 | : 100 | : 3) | ← | ← |
| Lingual 〃 | 0.0 | 50.0± 0.0 | 13.1±2.4 | 5.6±0.0 | 23. 3± 1.4 |
| | ( 0 | : 100 | : 26) | ← | → |

(← Toward Buccal. → Lingual.)

and Fig. 4. Proportion of the pressure distribution on each of three spots was calculated in each tooth area.

2. Lateral force (from the buccal side to lingual side) application to the abutment tooth and to the denture tooth: With these same simulator and denture, pressure distribution under saddle and the amount of lateral excursion of the abutment tooth were simultaneously recorded, while 500 g lateral force, from buccal side to lingual side of the denture saddle, on each denture tooth area, by using force applicating transducer. These results are shown in Table 2 and in Fig. 5.

3. Vertical excursion of the denture saddle: Pressure distribution on the residual ridge under the saddle was recorded, while 50$\mu$ vertical excur-

Table 2. Pressure distributions under the saddle and amount of lateral excursion of the abutment tooth when a 500 g lateral force is applied on each point. The mean values and standard deviations are shown. N=9

| Location of load (Lateral load) 500 g. buccal to lingual | Pressure amount under saddle (g/π cm²) | | | Lateral excursion (μ) | |
|---|---|---|---|---|---|
| | Buccal | Crest | Lingual | $\overline{4}$ | $\overline{5}$ |
| $\overline{4}$ | 7.14± 0.12 | 0.00 | 0.00 | 42.86±0.00 | 22.17± 1.88 |
| $\overline{5}$ | 9.17± 2.71 | 0.00 | 0.00 | 14.29±0.00 | 103.10± 8.40 |
| $\overline{6}$ area | 54.24±10.35 | 0.00 | 0.00 | 10.72±0.00 | 46.48± 3.06 |
| $\overline{7}$ 〃 | 74.92±10.30 | 0.00 | 0.00 | 12.50±0.00 | 75.00± 0.00 |
| $\overline{8}$ 〃 | 41.67±10.21 | 0.00 | 0.00 | 66.67±0.00 | 129.17±14.43 |

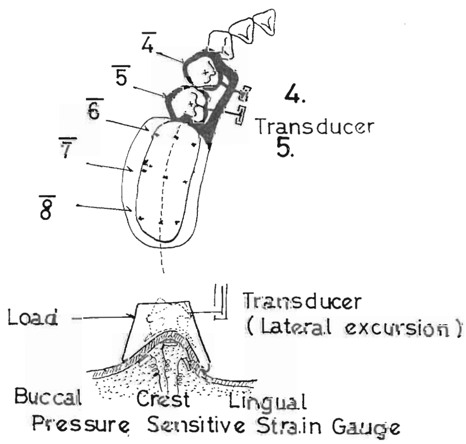


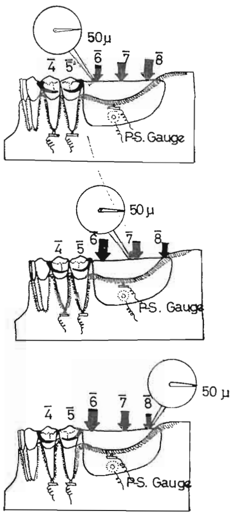

Fig. 5. Lateral forces applied on the same simulated model.

sion of the denture saddle was given by the application a vertical force on the occlusal table, using the force applicating transducer. The amount of vertical excursion of denture saddle against a constant load of 500 g was observed. These results are shown in Table 3 and in Figs. 6 and 7.

## Discussion

For the purpose of analyzing the relation between the pattern of the occlusal table of the unilateral distal extension saddle type of removable partial denture and pressure distribution on the residual ridge and abutment tooth was observed by using a specially designed pressure recording system, a tooth mobility indicator and its recording system, previously reported by the author. In a study on the distal extension saddle denture,

Table 3. Vertical excursion of the saddle when a vertical force is applied on the occlusal table shown by mean values and standard deviations. N=9




| Vertical excursion | | Vertical load (g) | Pressure amount under saddle | | |
|---|---|---|---|---|---|
| | | | Buccal | Crest ($g/\pi\ cm^2$) | Lingual |
| 50.0 μ | $\overline{6}$ | 400.0± 0.0 | 40.0±0.0 | 146.7±15.3 | 3.3±0.0 |
| | $\overline{7}$ | 436.7±40.0 | 19.3±1.2 | 220.0±17.3 | 4.0±0.0 |
| | $\overline{8}$ | 450.0± 0.0 | 4.0±0.0 | 120.0±0 .0 | 4.0±0.0 |
| 50.0 μ | $\overline{6}$ | 380.0± 0.0 | 48.0±0.0 | 160.0±11.3 | 3.3±0.0 |
| | $\overline{7}$ | 300.0± 0.0 | 8.0±0.0 | 150.0± 0.0 | 3.3±0.0 |
| | $\overline{8}$ | 250.0± 0.0 | 4.0±0.0 | 80.0± 0.0 | 1.0±0.0 |
| 50.0 μ | $\overline{6}$ | 500.0± 0.0 | 50.0±0.0 | 230.0± 0.0 | 7.0±0.0 |
| | $\overline{7}$ | 350.0± 0.0 | 12.0±0.0 | 120.0± 0.0 | 3.0±0.0 |
| | $\overline{8}$ | 190.0± 0.0 | 8.0±0.0 | 80.0± 0.0 | 2.0±0.0 |

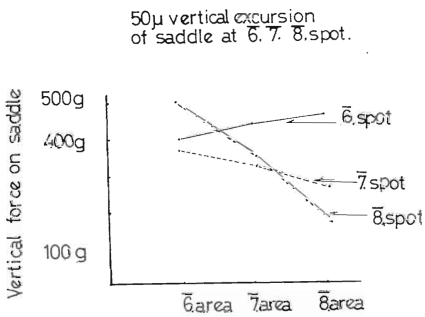



Fig. 6. Vertical forces on each area for 50 μ denture displacement, shown by a mean value.

Kaires[12] indicated a reduction in the size of occlusal table for reducing the force acting on the partial denture and for lessening the stress on the abutment teeth and soft tissues. His report did not indicate the proportional distribution of a transmitting forces between the residual ridge and abutment teeth, and experimental data were not given for the reduction of the bucco-lingual width of the artificial tooth.

The present author reported pressure distribution on the residual ridge and the amount of the displacement of the soft-tissue under the impression procedures, using the same simulated mandibular model[18], and also the

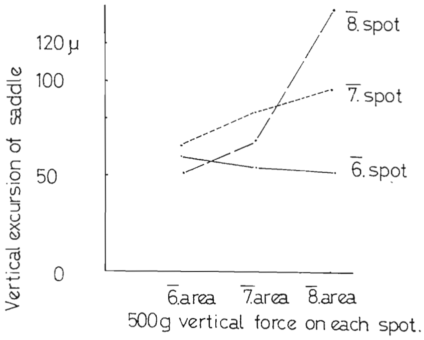



Fig. 7. Amount of vertical excursion against 500-g vertical loading, converted from Table 3.

lateral excursion of the abutment tooth when using the unilateral distal extension saddle type of the denture[7,8]. These previous data were also taken into consideration in the present work as a reference.

In the present investigation, the resiliencies of residual ridge and tooth supporting tissue of the simulated model were compiled from the data of clinical observation[16], and the most routine design of unilateral distal extension saddle type denture was used for this investigation. From the results of pressure distribution under the saddle, a rather high proportion was observed on the crest spot than on the other two spots, when a vertical pressure was applied on the occlusal table. Concerning the results of pressure distributions in the clinical impression procedure[18], the most optimal pressure distribution was observed when a vertical force was applied on the crest spot of the occlusal table. When a vertical force was applied on the buccal or lingual spot on each tooth area, an excess pressure was indicated under the corresponding area on the residual ridge of the simulated model. For example, pressure distribution under the resin custom tray with rubber base impression material was as following proportion: 3:10:3=buccal spot: crest spot: lingual spot. The most remarkable result of this investigation was the relationship between the lateral transmitting force to the abutment tooth and the location of the loading spots on the occlusal table of the denture saddle. When a 500 g vertical force was applied on the buccal side of the first molar area, the first premolar, as the abutment tooth of the indirect retainer, and the second premolar, as the abutment tooth of the direct retainer, both moved toward the buccal side. Though, the amount of the excursion of the direct retainer was much larger than that of the indirect retainer. The amount of excursion of the indirect retainer was about one quarter of that in direct retainer, when the vertical force was applied on the buccal spot of the first molar area. But when a vertical force was applied

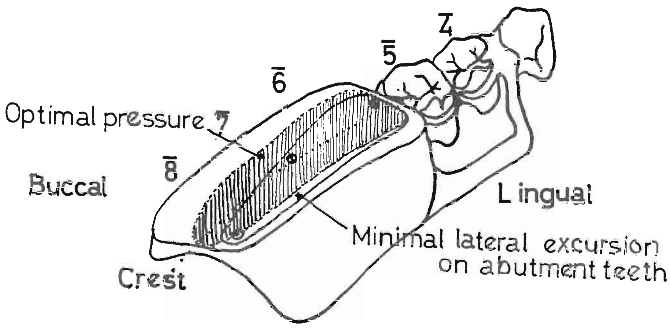



Fig. 8. The most rational occlusal table pattern, indicated by using a minimal lateral excursion of the abutment teeth and optimal load distribution under the saddle, on the simulated model.

on the buccal spot of the third molar area, the most distal area on the saddle, the amount of excursion of the indirect retainer increased about five times larger than that of the first molar area loading. The amount of excursion in direct retainer increased by distal loading on the occlusal table. The lateral excursion of the abutment tooth when a vertical force was applied on the crest spots was markedly different. When a vertical force was applied on the crest spot of the first molar area, the direction of lateral excursion of the abutment teeth was toward the lingual side. Though when the same load was applied on the second molar area, the direction of the excursion of the second premolar was toward the lingual side but that of the first premolar was towards the buccal side. And the amount of the excursion on that loading decreased, especially in that of the indirect retainer. When the loading was on the third molar, however, the direction of excursion of both abutment teeth was towards buccal side, but the amount of excursions increased, chiefly that of the indirect retainer was remarkable. When the vertical forces were applied on the lingual spots, the largest amount of the lateral excursion was observed in the second premolar. But when the loading point was in distal area, the amount of lateral excursion decreased markedly. And when the loading point located on the third molar area, the excursion of the direct retainer was towards the buccal side. The amount of the excursion in direct retainer increased, but that in indirect retainer decreased. Results of the alteration in the direction of lateral excursion indicated a change in the location of the fulcurm on the rocking axis of the denture saddle. These results suggested the most important concept for the occlusal pattern of the unilateral distal extension saddle. Considering these results of the pressure distribution under the saddle and the transmitting force against the abutment teeth while a vertical force was applied on the occlusal table of this type denture, the most rational pattern of the occlusal table area was indicated experimentally as shown in Fig. 8. This pattern was spotted by observing the minimal lateral excursions of the abutment teeth and the most optimal pressure distribution under saddle on the recording chart papers.

With respect to the lateral force from the buccal to the lingual against the denture tooth area, pressure distribution under the saddle indicated completely one-sided on the buccal side of the residual ridge. The amount of lateral excursion of the abutment tooth when a lateral force was applied on the buccal surface of the denture saddle was markedly larger than that from a vertical force, and excursion of the first premolar as the indirect retainer was especially increased by distal loading.

The results of the vertical excursion of the distal extension saddle indicated the relation between the effects of the retainer, tooth-borne, and withstanding soft tissue, tissue-borne. The amount of vertical excursion increased markedly in distal area of the saddle against a vertical loading, but non-linear relation was observed between the distance from the distal contour of the second premolar to loading point and the amount of vertical excursion of the denture saddle. This result indicated that the distal end of the occlusal rest was not represented as the fulcurm of distal tooth tipping on this type of a denture.

## Conclusion

This investigation was carried out for the purpose of analyzing the functional behavior of the removable partial denture with unilateral extension saddle. Chiefly the relation between the functional pattern of the occlusal table and its transmitting force to the residual ridge and abutment teeth was examined in this investigation. A simulated model, the unilateral mandibular extension saddle was devised for this purpose. Special devices for measuring the tooth mobility, force applicator, and their recording system were those reported in previous papers.

The conclusions were as follows:

1. The optimal load distribution against the residual ridge from the denture saddle was observed when a vertical force was applied on the crest spot of the occlusal table.

2. Reduction in bucco-lingual width of the occlusal table, especially in distal area, was quite effective in reducing the lateral transmitting force to the abutment teeth, and in making rational proportion of the distribut-

ing pressure against the residual ridge.

3. Lateral force against the distal extension saddle gave a remarkable stress to the abutment teeth, and an excess pressure distribution under the corresponding area of the residual ridge was observed.

4. The amount of vertical excursion of the distal extension saddle of the denture when a vertical load was applied on the occlusal table was highly related to the location of the loading point.

5. The distal end of the occlusal rest did not represent the fulcrum of distal tooth tipping on this type of a denture.

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