A study from a case report on the basic concept and design of removable partial dentures: Support and bracing considerations

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Case Report

ABSTRACT:

During the design of removable partial dentures, it is necessary to maximize the effectiveness of support and bracing as a strategy to minimize denture movement. Therefore, it is necessary to emphasize the importance of providing patients with appropriate, safe, and secure removable partial dentures, and have clinicians re-recognize the concept and importance of support and bracing. This case report presents extension-base removable partial dentures and describes the effect of support and bracing action in denture design, which is important for minimizing denture movement. The case report, and an accompanying literature review, emphasizes the importance of utilizing the contact between the axial surface of the abutment tooth and denture components to provide an effective support and bracing action. The case report and literature review also highlight the importance of improving the bracing action by connecting the minor connector and proximal plate with the guiding plane set for multiple teeth (frictional control), controlling the direction of denture during the placement/removal (path of insertion), and considering the major connector form to improve the support and bracing actions. Additionally, effective support and bracing actions are necessary not only for the retainer part but also for the denture components, including the design of the denture base and major connector. Removable partial dentures with “frictional control” and “path of insertion” are expected to reduce denture movement and improve stability.

Keywords: removable partial denture, support, bracing, denture design, case report

INTRODUCTION:

In tooth-tissue-supported removable partial dentures, the attachment of denture to the abutment teeth results in varying amounts of tissue displacement in the periodontal ligament and the residual ridge under the denture base. To ensure even distribution of occlusal pressure during function, it is necessary to ensure that the pressure is equitably distributed across the denture. Achieving a harmonious and simultaneous occlusal contact relationship between the denture and remaining teeth, including the abutment tooth, requires an environment that can compensate for the differences in tissue displacement between the abutment tooth and the supporting elements of the denture [1-3]. Furthermore, the denture must resist occlusal pressure to suppress sinking (support), lateral force to prevent lateral movement (bracing), and vertical force to prevent surfacing (retention) [4]. It is important to consider the denture design in terms of support, bracing, and retention [4]. Specifically, the procedure involves the use of a rest, denture base, minor connector, proximal plate, major connector, and extracoronal retainer (retentive clasp). As a result, when a functioning removable partial denture is completed, the functional occlusal pressure loading on the denture base is reduced by both the support from the abutment tooth through the occlusal rest and the support from the tissue of the residual ridge [5-7].

Most clinical cases of removable partial dentures involve extension-base removable partial dentures (tooth-tissue-supported removable partial dentures) [8-10]. As such, denture design should be devised in a way that allows the elements of the support and bracing action to be fully utilized, with attention to the bracing effect that results from the contact between the axial surface of the abutment tooth and the denture structure. The author believes that this approach can lead to a minimization of denture movement, resulting in greater stability of the dentures.

In removable partial denture design, support and bracing must be considered as fundamental principles. In several studies on the effects of guiding planes and proximal plates on clasp retention, it has been reported that the retentive force was kept when the guiding plane and the proximal plate were well adapted [Mothopi-Peri and Owen 11, 12]. Clinicians must acknowledge that minimizing denture movement requires increasing support and bracing action. By restricting the movement of the denture, sufficient retention can be expected without requiring excessive force in the undercut portion of the abutment tooth (frictional control).

This study aimed to describe the effect of support and bracing action in removable denture design, which is important for minimizing denture movement, and explain how these principles can be applied in clinical practice. Case examples are provided from the author's clinical practice and denture design is reviewed based on textbooks, as well as a literature search conducted on PubMed.

CASE PRESENTATION:

Clinical cases in which it was possible to suppress denture movement by increasing the support and bracing actions of a denture design are described herein. All patients described herein provided written informed consent for the use of personal or clinical details along with any identifying images for publication in this study. There are no medical, family, psycho-social history, genetic information.

Case 1

A 51-year-old woman visited the university dental hospital with the chief complaint of masticatory disturbance due to her inadequately fitting, unstable dentures (Fig. 1a). No abnormalities were observed in the periodontal tissue based on the periodontal pocket probing, tooth mobility test, or bleeding on probing of the remaining mandibular teeth; however, an inadequately fitting bridge was attached from the first premolar on the right side of the mandible to the first premolar on the left side as abutment teeth. Radiological examination (orthopantomogram) was performed to confirm an inadequately fitting bridge; moreover, no abnormal findings were observed in the edentulous ridge. Therefore, the patient was diagnosed with masticatory disorder due to inadequately fitting dentures in the mandible and inadequately fitting bridge. Prosthetic treatment of the mandibular inadequately fitting bridge and mandibular denture was planned. A porcelain-fused-to-metal restoration, on which rest seats were applied, was used as the abutment tooth to make a bridge (Fig. 2a). Following the successful placement of the mandibular bridge on the abutment teeth, a functional impression was taken, incorporating border molding of the mandibular extension-base removable partial denture. Concurrently, the bridge was secured, and a precise working model was crafted. The mandibular major connector was designed as a lingual plate, with rest proximal plate I bar (RPI) clasps as direct retainers on the right side of the mandible second premolar and on the left side of the mandible second premolar as abutment teeth (Fig. 2a,b). A rest was also applied to the left first premolar as an indirect retainer (Fig. 2a,b). For artificial teeth, composite resin teeth were selected (Endura posterior; Shofu Japan). The completed final denture is shown after it was inserted and fitted in the mouth (Fig. 2c,d). Its design controls the direction of denture placement/removal by maintaining frictional control. Intervention adherence and tolerability in terms of denture comfort and problems were assessed verbally at each visit. Subsequently, denture occlusion tests and denture basal surface conformity tests were performed each time to check for any abnormalities. In addition, oral hygiene inspections and maintenance, as well as masticatory function tests, were conducted to confirm that the patients were able to eat without any problems. The patient is being followed up for maintenance and no problems have been noted.

Case 2

A 67-year-old man visited the university dental hospital with the chief complaint of missing dentures (Fig. 1b). The patient was diagnosed with masticatory disorder in the mandible. No abnormalities were observed in the periodontal tissue based on the periodontal pocket probing, tooth mobility test, or bleeding on probing of the remaining mandibular teeth. Radiological examination (orthopantomogram) was performed to confirm the remaining teeth; moreover, no abnormal findings were observed in the edentulous ridge. Since the treatment was limited by the patient's wishes, a resin-made mandibular extension-base removable partial denture was designed using acrylic resin. The mandibular right lateral incisor, left canine, and first and second premolars were used as abutment teeth. A functional impression with border molding was taken after applying the guiding plane and rest seat to the abutment teeth. The completed final denture was a lingual plate major connector made of resin material, wrought wire clasps of the right lateral incisor, double Akers clasps of the left first and second premolars as direct retainers, and embrasure hooks of the left canine as indirect retainers. In order to correct the occlusal plane of the mandibular left second premolar, a cap clasp made of indirect composite resin was combined with a double Akers clasp that the design controls the direction of denture placement/removal by maintaining frictional control. For artificial teeth, composite resin teeth were selected (Endura posterior; Shofu Japan). In addition, to prevent bending and breakage of the resin base denture, a reinforcement metal plate (diameter: 3 mm, thickness: 1.5 mm) was inserted to improve strength. Intervention adherence and tolerability for denture comfort and problems were assessed verbally at each visit. Subsequently, denture occlusion tests and denture basal surface conformity tests were performed each time to check for any abnormalities. In addition, oral hygiene inspections and maintenance, as well as masticatory function tests, were conducted to confirm that the patients were able to eat without any problems. The patient is followed up for maintenance and no problems.

Case 3

A 54-year-old man visited the university dental hospital with the chief complaint of masticatory disturbance due to inadequately fitting, unstable dentures. No abnormalities were observed in the periodontal tissue of the remaining mandibular teeth based on periodontal pocket probing, tooth mobility test, or bleeding on probing; however, inadequately fitting crowns in the mandibular right second molar, first premolar, canine, lateral and central incisor, and left central incisor were observed. Radiological examination (orthopantomogram) was performed to confirm the inadequately fitting crowns. Meanwhile, no abnormal findings were observed in the edentulous ridge. Therefore, masticatory disorder due to inadequately fitting dentures in the mandible and inadequately fitting crown was diagnosed. A new mandibular denture and connecting resin-veneered restoration was planned with milling on the axial lingual surface. A crown and connecting crowns with milling were fabricated, to which the guiding plane was applied as the abutment tooth. After the mandibular crown and connecting crown were applied to the abutment teeth, a functional impression with border molding of the extension-base removable partial denture was taken. Concurrently, a working model of the crown and connecting crown was made. The mandibular major connector was designed as a Kennedy bar and Akers clasps were designed for the right second molar and right first premolar as direct retainers. Akers clasps were also designed for the right canine as indirect retainers. The design controls the direction of denture placement/removal by maintaining frictional control. For artificial teeth, composite resin teeth were selected (Endura anterior, posterior; Shofu Japan). The completed final denture inserted and fitted in the mouth is shown in Fig. 1c. Intervention adherence and tolerability in terms of denture comfort and problems were assessed verbally at each visit. Subsequently, denture occlusion tests and denture basal surface conformity tests were performed each time to check for any abnormalities. In addition, oral hygiene inspections and maintenance, as well as masticatory function tests were conducted to confirm that the patients were able to eat without any problems. The patient is followed up for maintenance and no problems have been noted.

Case 4

A 72-year-old woman visited the university dental hospital with the chief complaint of masticatory disturbance due to inadequately fitting, unstable maxillary dentures. No abnormalities were observed in the crown fitted from the right maxillary canine to the left canine, periodontal tissue based on periodontal pocket probing, tooth mobility test, or bleeding on probing, and residual mucous membrane. Radiological examination (intraoral radiographic image, orthopantomogram) was performed to confirm the remaining teeth; moreover, no abnormal findings were observed in the edentulous ridge. Therefore, the patient was diagnosed with masticatory disorder due to inadequately fitting dentures in the maxilla. The treatment plan was to perform prosthetic treatment of the maxillary inadequately fitting denture. After adding a guiding plane and cingulum rest seat for canines on both sides, a functional impression with border molding of the extension-base removable partial denture was taken. The maxillary major connector was designed as a palatal plate, with RPI clasps with cingulum rests of the canines as direct retainers on both sides. These clasps were installed to provide frictional retention on the lingual and distal axial surfaces of the abutment teeth. The design controls the direction of denture placement/removal by maintaining frictional control. For artificial teeth, composite resin teeth were selected (Endura posterior; Shofu Japan). The completed final denture inserted and fitted in the mouth is shown in Fig. 3a. Intervention adherence and tolerability in terms of denture comfort and problems were assessed verbally at each visit. Subsequently, denture occlusion tests and denture basal surface conformity tests were performed each time to check for any abnormalities. In addition, oral hygiene inspections and maintenance, as well as masticatory function tests, were conducted to confirm that the patients were able to eat without any problems. The patient is followed up for maintenance and no problems have been noted.

Case 5

A 82-year-old woman visited the university dental hospital with the chief complaint of masticatory disturbance due to inadequately fitting, unstable maxillary dentures following tooth extraction in the right maxillary molar region. The patient was also concerned about the appearance of an incompatible left central and lateral incisor crown. No abnormalities were observed in the periodontal tissue of the remaining maxillary teeth based on periodontal pocket probing, tooth mobility test, or bleeding on probing. Radiological examination (intraoral radiographic image, orthopantomogram) was performed to confirm the remaining teeth, moreover, no abnormal findings were observed in the edentulous ridge. Therefore, the patient was diagnosed with masticatory disorder due to maxillary right posterior tooth extraction and aesthetic disorder due to an inadequately fitting crown of the maxillary anterior teeth. The treatment plan was to perform prosthetic treatment of the maxillary inadequately fitting crown and maxillary dentures. After fabricating two ceramic crowns for the maxillary anterior teeth, the cingulum rest seat for the maxillary left canine, occlusal rest seat for the second premolar distally, and occlusal rest seat for the distal first molar and the mesial second molar were installed. After the completed maxillary crowns were applied to the abutment teeth, a functional impression with border molding of the maxillary extension-base removable partial denture was taken, and concurrently, working models of the crowns were made. The maxillary major connector was designed as a palatal plate; it was used to continuously extend and contact the axial surface of the residual tooth. Cingulum rests for the left central and lateral incisors as direct retainers, Akers clasp with cingulum rest for the left canine as indirect retainer, Akers clasp with occlusal rest for the second premolar distally as indirect retainer, and double Akers clasps with occlusal rests for the distal first molar and mesial second molar as indirect retainers were installed. The design controls the direction of denture placement/removal by maintaining frictional control. For artificial teeth, composite resin teeth were selected (Endura anterior, posterior; Shofu Japan). The completed final denture inserted and fitted in the mouth is shown in Fig. 3b. Intervention adherence and tolerability in terms of denture comfort and problems were assessed verbally at each visit. Subsequently, denture occlusion tests and denture basal surface conformity tests were performed each time to check for any abnormalities. In addition, oral hygiene inspections and maintenance, as well as masticatory function tests, were conducted to confirm that the patients were able to eat without any problems. The patient is followed up for maintenance and no problems have been noted.

Case 6

A 55-year-old man visited the university dental hospital with the chief complaint of masticatory disturbance due to inadequately fitting, unstable dentures. No abnormalities were observed in the periodontal tissue of the remaining maxillary teeth based on periodontal pocket probing, tooth mobility test, or bleeding on probing; however, an inadequately fitting crown was attached to the maxillary right first molar, and an inadequately fitting bridge with maxillary left canine, first premolar, and first molar as abutment teeth was found. Additionally, the bilateral maxillary tubercles were remarkably bulging, and it was difficult to extend the denture base. Radiological examination (intraoral radiographic image, orthopantomogram) was performed to confirm an inadequately fitting bridge; moreover, no abnormal findings were observed in the bone quality of the edentulous alveolar ridge. Therefore, the patient was diagnosed with masticatory disorder due to inadequately fitting maxillary dentures and inadequately fitting maxillary crown and bridge. A new maxillary denture, right maxillary complete metal crown with milling on the axial lingual surface, and left maxillary porcelain-fused-to-metal restoration with milling on the axial lingual surface were planned. A crown and bridge, milled with a guiding plane applied to the abutment tooth, was fabricated. Following the completion of the maxillary crown and bridge placement on the abutment teeth, a functional impression with border molding was taken. Simultaneously, the crown and bridge were secured, and a precise working model was crafted. The maxillary major connector was designed as a palatal plate, with Akers clasps for the right molars as direct retainers, a cingulum rest for the left canine as direct retainer, and Akers clasp for the left first premolar as indirect retainer and first molar as direct retainer (Fig. 4a,b). The design controls the direction of denture placement/removal by maintaining frictional control. For artificial teeth, composite resin teeth were selected (Endura anterior, posterior; Shofu Japan). The completed final denture inserted and fitted in the mouth is shown in Fig. 3c. Intervention adherence and tolerability in terms of denture comfort and problems were assessed verbally at each visit. Subsequently, denture occlusion tests and denture basal surface conformity tests were performed each time to check for any abnormalities. In addition, oral hygiene inspections and maintenance, as well as masticatory function tests, were conducted to confirm that the patients were able to eat without any problems. The patient is followed up for maintenance and no problems have been noted.

DESIGN OF REMOVABLE PARTIAL DENTURES:

The design of removable partial dentures is based on the following principles: (1) The support element is determined by the rest sheet set on the abutment tooth, and the outline shape of the denture base is determined by impression making. (2) Bracing elements are added to prevent the movement in the vertical and lateral direction. This includes the bracing clasp of the abutment tooth, contact between the guiding plane and proximal plate, and selection of rigid and hard major connectors. (3) Providing a retaining element that resists the vertical force acting on the denture base (Fig. 5). It has been reported that if the support and bracing factors are adequately addressed, it is sufficient to set a minimum holding force [7]. Therefore, the basic procedure for designing dentures is as follows: rest/denture base (support action), followed by the minor connector/proximal plate/major connector (bracing action), and finally, the extracoronal retainer (retentive clasp, retentive action). In daily clinical practice, after the denture is designed following these basic rules, the prosthetic rehabilitation using removable partial denture is done [7,13].

DENTURE DESIGN CONSIDERING IMPROVEMENT OF SUPPORTING AND BRACING ACTION:

Support action

Complementarity plays an important role with the support element acting as both as a tooth (similar to periodontal ligament) to support the rest on the abutment tooth and as a residual ridge to support the denture base and major connector [14-16]. To minimize the impact of occlusal loading on the abutment teeth caused by the pressure exerted on the denture base during function, it is necessary to minimize soft tissue displacement beneath the denture base during occlusion and reduce the difference between tissue displacement under the denture base and the abutment teeth [17,18]. By minimizing displacement, simultaneous occlusal contact between the denture base and the abutment teeth can be achieved during function [6,7,19-21] (Fig. 6). For this purpose, it is clinically important to compensate for the difference in pressure displacement between the abutment tooth and the alveolar ridge mucosa by using functional impression method during the fabrication of removable partial denture. As a result, it is possible to disperse the functional occlusal force so that the transmission direction during function is in the axial direction of the abutment tooth and the vertical to the alveolar ridge mucosa [19-21].

Bracing action

To minimize denture movement, it is important to utilize the bracing action by making contact between the axial surface of the abutment teeth and the minor connector, proximal plate, and the major connector between the lingual and palate axial surfaces of the abutment teeth [22-24]. Additionally, it is important to utilize bracing clasps designed for an effective bracing action.

The contact of the axial surface of the abutment tooth (guiding plane) with the minor connector, proximal plate, and major connector restricts the placement/removal and movement direction of the denture, thus suppressing denture movement, including lifting and separation [7,25,26].

Utilizing contact area between the axial surface of the abutment teeth and the denture components to improve bracing effect, the guiding planes are designed to establish multiple contact points between the guiding plane of the axial surface of the abutment teeth and the denture components (minor connector and proximal plate). As a result, the dentures (path of insertion and path of placement) become difficult to lift and separate in any direction other than the one dictated by the guiding plane. This effectively restricts the placement/removal direction of dentures, suppressing their lateral movement, and providing excellent bracing action. Furthermore, major connectors effectively and appropriately distribute the functional load applied on the denture by covering the residual lingual surface (palatal surface) extensively.

Moreover, the lingual and palatal plates have a continuous and wide contact with the axial surfaces of the abutment teeth that resist the lateral force applied to the denture, providing effective bracing action. In terms of reciprocation, it is important to place a bracing clasp (reciprocal clasp) on the survey line on the lingual surface or on the formed guiding plane (both in the undercut and non-undercut area), opposing the retentive clasp attached to the abutment tooth.

PRACTICE DENTURE DESIGN BASED ON BRACING ACTION:

Maintaining friction on parallel surfaces (frictional control)

Figure 4 (a,b) shows a clinical case (surveyed crown) where a part of the crown contour was processed with a milling device to ensure parallel alignment of the lingual and mesio-distal axial surfaces of each abutment tooth of the maxillary dentition [27]. Multiple rests and guiding planes were set parallel to the direction of denture placement/removal to regulate its direction of movement [28]. This enhances the bracing action through contact with the axial surface of the abutment tooth and multiple rests to ensure denture stabilization during function [29].

Among the denture components, the minor connector and proximal plate provide frictional control [7,29-31] by maintaining contact with the guiding plane on the axial surface of the abutment teeth, which in turn controls the movement direction and minimizes movement during denture functioning. Moreover, by restricting the direction of placement/removal (path of placement and removal) [6,7,12,29,32], the denture becomes less likely to be lifted and separated (Fig. 7a,b,c).

Figure 2 (a,b,c,d) represents an example of a design that controls the direction of denture placement/removal by maintaining friction on parallel surfaces (frictional control). The abutment tooth side is a surveyed crown [33-39] designed with a guide plane and mesial rest (Fig. 2a) to maintain friction on surfaces parallel to the denture components (minor connector, proximal plate, and major connector) (Fig. 2b). The denture design incorporates the concept of structural design (Fig. 2b), with the major connector designed as a lingual plate due to the distance from the gingival margins to the floor of the mouth being less than 7 mm (Fig. 2a,b). The continuous contact of the major connector with the tooth surface regulates the direction of denture placement/removal, as seen from the lingual view (Fig. 2c,d).

Reciprocation

Figure 8 shows three cases of reciprocation in the retentive and bracing clasps (reciprocal clasps). The bracing clasp that opposes the retentive clasp on the buccal side can be designed in a plate-like shape with vertical width, as shown in Fig. 8a, to improve the bracing action and suppress the lateral movement of the denture. Similarly, a plate-shaped bracing clasp with a vertical width can be designed in combination with the denture base (metal-based or acrylic resin-based) to suppress lateral movement, as shown in Fig. 8b. From the viewpoint of vertical and lateral reciprocation of denture placement/removal, the bracing clasp is desirable in the shape of a plate with a vertical width [6,7,22]. Additionally, the bracing clasp can also be designed as a lingual plate, which is the major connector shown in Fig. 8c, that opposes the buccal retentive clasp and extends on the lingual axial surface toward the occlusal side.

Therefore, it is necessary for both the retentive clasp arm and the bracing clasp arm to simultaneously contact the axial surface to protect the abutment tooth and prevent buccolingual movement [6,7,22]. This phenomenon, known as reciprocation, is a necessary design requirement for clasp elements and plays a crucial role during denture placement/removal.

Major connectors

In daily clinical practice, cases with multiple missing teeth in the anterior and molar regions of the maxillary and mandibular arches are frequently encountered (Fig. 1,3). In such cases, it is often difficult to minimize denture movement using direct or indirect abutments alone. Therefore, it is desirable to provide support and bracing action by the major connector [7,37]. In the mandibular region, as shown in Fig. 1a and b, a plate-shaped major connector is designed to be continuously extended to contact the axial surface of the remaining tooth. The methodology for designing the major connector in the maxillary region is essentially the same as that of the mandibular region. As shown in Fig. 3a and b, to prevent lateral movement of the denture and lifting or separation at the posterior end of the denture base, a plate-shaped major connector was used to continuously extend and contact the axial surface of the residual tooth. These are important considerations when designing the form of major connecters. Additionally, as shown in Fig. 1c and 3c, milling on the axial surface of the abutment tooth may enhance the bracing effectiveness of the major connector design in some cases.

DISCUSSION:

This paper presents the principles of removable partial dentures design using clinical cases from the author's clinical practice, emphasizing the crucial role of support and bracing in minimizing denture movement.

As shown in the clinical examples presented in this paper, removable partial dentures with clasps applied to the retainer belong to the category of flexible connections. However, by enhancing the effect of both support and bracing action, it is possible to improve the connection strength and achieve a condition close to a rigid connection, thereby minimizing denture movement. Furthermore, this paper highlights the role of a plate-shaped major connector that contacts the axial surface of the abutment tooth. This improves the bracing action, thereby contributing to the minimization of denture movement. This approach incorporates the concept of structural design into the removable partial denture prostheses. While the reference paper cited in this study discusses the design of removable partial dentures, few include actual clinical cases like the ones presented here. Therefore, the author believes that this case study offers valuable insight and clinically significant, potentially enhancing prosthetic treatment for removable partial dentures.

When designed to provide sufficient support and bracing action, such dentures exhibit adequate stability in the mouth. Establishing multiple contact points between the guiding plane of the abutment teeth and the denture components (frictional control) enhances the bracing action and clarifies the dentures' placement/removal direction (path of placement and removal).

In this study, the author proposes a denture design that emphasizes bracing action through contact with the axial surface of the abutment tooth, depending on the shape, particularly for major connectors and denture bases among denture components with bracing action. Contact with the axial surface of the tooth, parallel to the dentures' placement/removal direction, not only suppresses lateral movement when the denture is in a fixed position but also governs the dentures' placement/removal direction (path of placement and removal) [6, 7] [Table 1].

From the perspective of minimizing denture movement, regulating the movement direction is an essential and critical requirement in denture design.

Preventive dentistry is one of the factors to consider when designing removable partial dentures [38-40]. In designing mandibular major connector, either the lingual bar or lingual plate should be selected based on the distance from the gingival margin of the remaining tooth to the floor of the mouth [6,7]. If there is no issue with the position of the gingival margin of the remaining tooth, the lingual bar, which has excellent self-cleaning action, is considered the first choice. However, there are many clinical cases where the superior support and bracing action of the lingual plate are more important than the cleanability and self-cleaning action of the lingual bar [7,29,37]. Therefore, when applying a plate-shaped major connector, it is important to ensure that the patient does not have extensive caries or advanced periodontal disease, and that they are capable of reliably and effectively controlling dental and denture plaque during home care maintenance. In addition, if it is not possible to secure enough retainers to minimize denture movement or if the residual ridges have poor support, it may be preferable to select a lingual plate to compensate for these factors.

In recent years, clinical research using crossover studies with lingual bars and lingual plates has been reported. This study clarifies that lingual plates do not directly aid in the growth of bacteria that cause periodontal disease when oral hygiene management is adequately performed [41]. Furthermore, a 30-year retrospective cohort study of fitted removable partial denture design at the University of Montreal School of Dentistry found that adequate oral hygiene management, instruction, and a planned maintenance system ensured adequate application of the lingual plate and maintenance of good oral health [42]. Based on the evidence presented in this section, the application of plate-shaped major connectors is an effective treatment strategy for removable partial dentures when strengthening the support and bracing action is the top priority.

In the clinical cases shown herein, the effect of suppressing the movement of dentures was demonstrated in all denture designs. In each case, the author explained the importance of the remaining teeth to the patient and provided instructions on oral hygiene before starting denture treatment. The author also explained the importance and handling of dentures to the patient, and the patients' understanding was confirmed during treatment and after wearing dentures, and consent was obtained before the treatment. After the treatment, the patient's motivation for oral hygiene and understanding of dentures improved compared to that before treatment, thus positively impacting the long-term prognosis after wearing dentures, and improving quality of life [38, 42].

In recent years, with the rise of the super-aging society, the number of individuals with remaining teeth has been increasing annually [43]. Removable partial denture treatment for missing teeth is an essential prosthetic dental treatment in everyday clinical practice, and its demand is expected to grow further [44]. Considering these factors, and acknowledging the limitations of this study, it is evident that the denture design principles outlined in this paper hold significant importance in the prosthetic treatment of removable partial dentures for missing dentition.

CONCLUSION:

In designing removable partial dentures, maximizing the support and bracing is required as a specific measure for minimizing denture movement. In this study, the importance of support and bracing effects that utilize the contact between the axial surface of the abutment tooth and the denture structure have been highlighted. These can be summarized as follows:

1) Improving the bracing action by contacting the minor connector and proximal plate with the guiding plane set for multiple teeth (frictional control) is crucial. It is also important to control the direction of denture during placement/removal (path of insertion).

2) It is important to consider the design of major connectors to improve the support and bracing action.

Therefore, in prosthetic rehabilitation using removable partial dentures, the combined action of support and bracing is required not only for the retainer but also for other denture components, including the denture base and major connector. It is also important to consider the equitable distribution of force during functioning.

Strategically designed removable partial dentures with frictional control and a defined path of insertion aim to minimize denture movement and enhance stability.

AUTHOR CONTRIBUTIONS

Jun Takebe: Dental treatment physician, investigation, methodology, project administration, validation, visualization/photography/clinical case management, manuscript writing/ review and editing.

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CONFLICT OF INTERES T

The author declares that there are no known competing financial interests or personal relationships that could have influence the work reported in this paper.

ETHICS STATEMENT

Informed consent for the use of photographic materials in dental education and research papers was obtained from the patient and recorded in the medical records. All patients in this study provided written informed consent for the use of personal or clinical details along with any identifying images for publication in this study.

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Key Clinical Message

In designing removable partial dentures, the importance of support and bracing effects that utilize the contact between the axial surface of the abutment tooth and denture structure is required as a specific measure for minimizing denture movement.

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FIGURE LEGENDS:

Figure 1

Clinical case of the bracing effect by the mandibular major connector.

a: Design example of a metal lingual plate for the major connector of a mandibular removable partial denture.

b: Design example of a resin lingual plate for the major connector of the mandibular removable partial denture.

c: Design example of a Kennedy bar made of metal with a milling technique applied to the major connector of the mandibular removable partial denture.

Figure 2

Bracing effect by minor connectors and proximal plates. Clinical case of frictional control.

a: The surveyed crown design on the abutment tooth side includes a guide plane.

b: The removable partial denture placement with the surveyed crown.

c, d: Lingual view of the removable partial denture. On the lingual surface of the removable partial denture, the proximal plate and the major connector (lingual plate) are important for maintaining friction (frictional control) with the axial surface of the abutment tooth.

Figure 3

Clinical case of bracing effect by the maxillary major connecter.

a: Design example of a metal palatal plate for the major connector of a maxillary removable partial denture.

b: Design example of a metal palatal plate continuously extended to contact the axial surface of the residual tooth for the major connector of the maxillary removable partial denture.

c: Design example of a metal palatal plate with a milling technique applied to the major connector of a maxillary removable partial denture.

Figure 4

A clinical case of each abutment tooth milled on the lingual and mesiodistal axial surfaces (blue line) of the maxillary dentition.

a: Each abutment tooth milled on the lingual and mesiodistal axial surfaces.

b: The bracing clasp (reciprocal clasp) as a direct retainer is fully seated and the lingual contour of the abutment teeth is restored.

Figure 5

Support and bracing play major roles in restraining denture movement.

The yellow arrows indicate the action of support. The blue arrows indicate bracing action. Green arrows indicate the retention action.

Figure 6

Occlusal force on dentures during function.

It is clinically important to compensate for the difference in tissue displacement between the abutment tooth and residual ridge using a functional impression method for the removable partial denture. As a result, the functional force can be dispersed in such a way that the transmission direction during function is in the axial direction of the abutment tooth and vertical direction of the residual ridge.

Figure 7

Bracing effect enhanced by minor connectors and proximal plates through friction on parallel surfaces (frictional control).

a: The abutment tooth side with a guide plane (the black lines denote the parallel surfaces).

b, c: Restriction of the placement/removal direction on the guide plane (path of insertion).

Figure 8

Reciprocation: The relationship between the retentive clasp and the bracing clasp.

The lingual portions of figures a, b, and c demonstrate the action of bracing.

a: The design of the bracing clasp.

Buccal: action of retention. Lingual: action of bracing.

b: The bracing clasp can be designed in combination with the denture base.

Buccal: action of retention. Lingual: action of bracing.

c: It is possible to design a lingual plate that can be extended on the lingual axial surface toward the occlusal side as a bracing clasp.

Buccal: action of retention. Lingual: action of bracing.

TABLE CAPTIONS:

Table 1

Bracing effect achieved through contact between the axial surface of the abutment tooth and the denture structure.

FIGURES:

Figure 1a

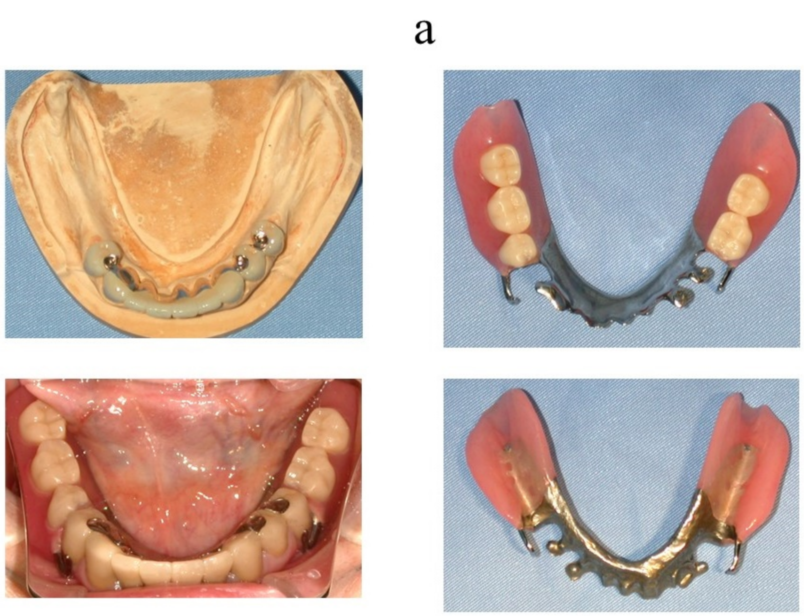


Figure 1b

b

Figure 1c

c

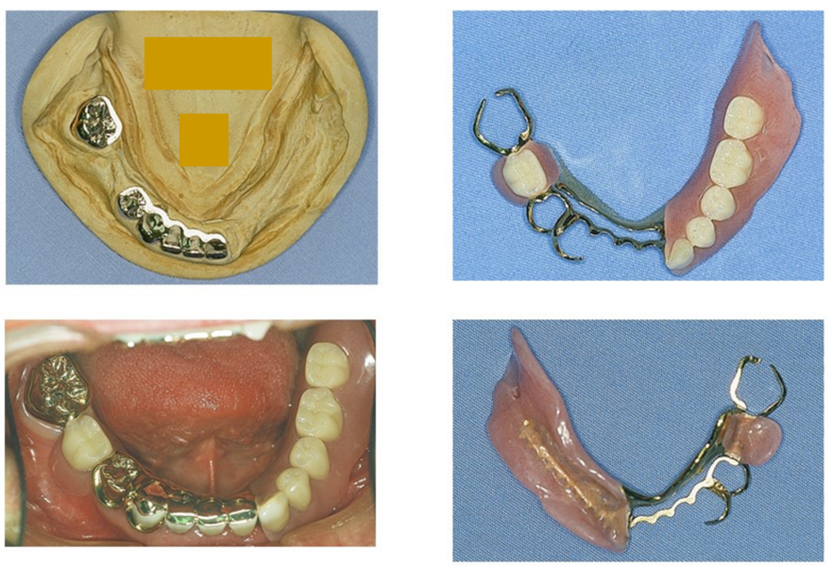


Figure 2

Figure 3a

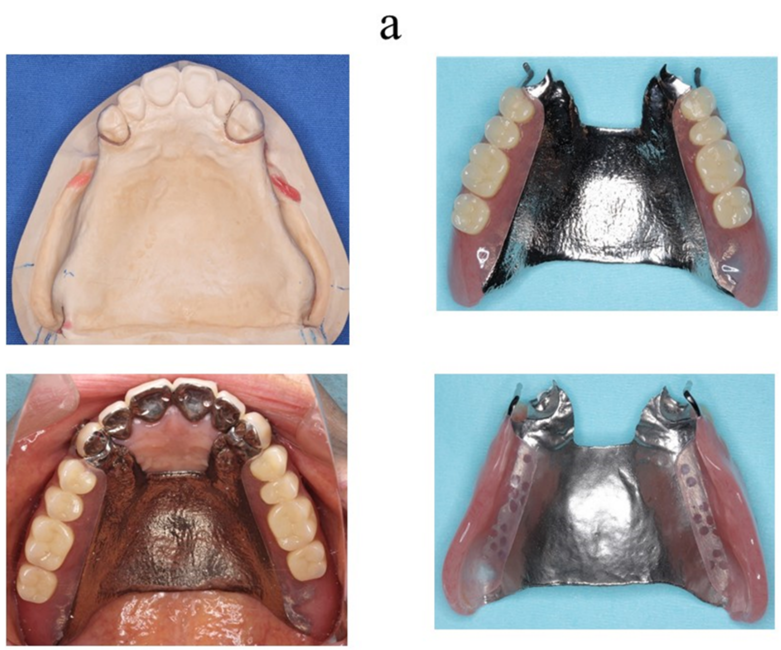


Figure 3b

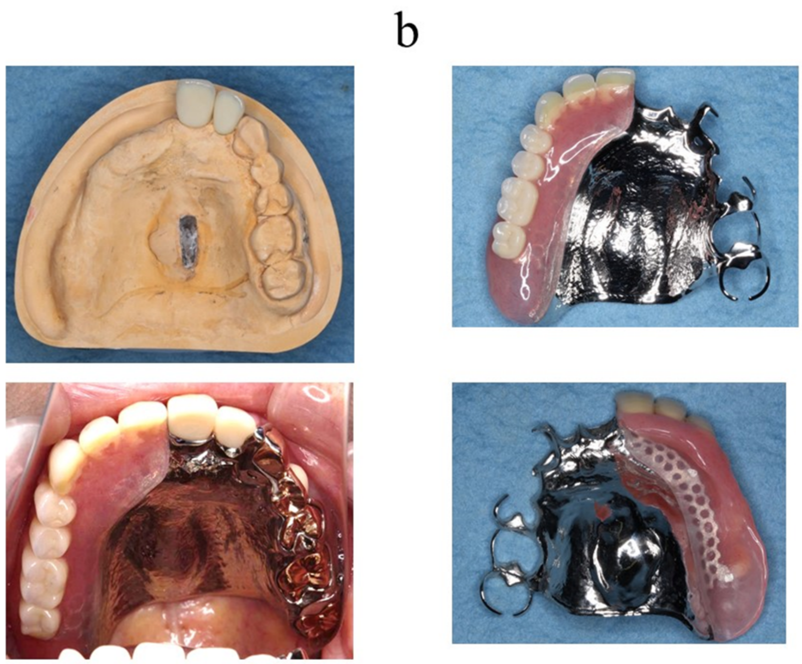


Figure 3c

c

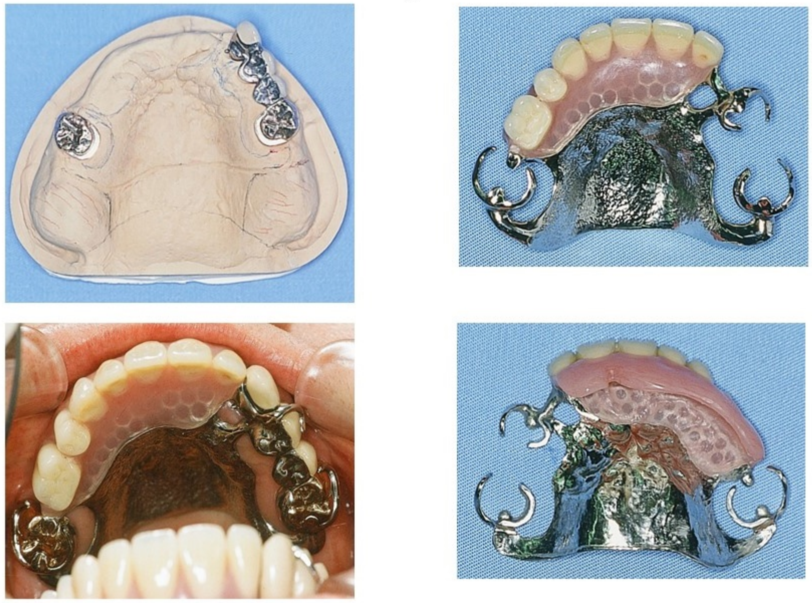


Figure 4

b

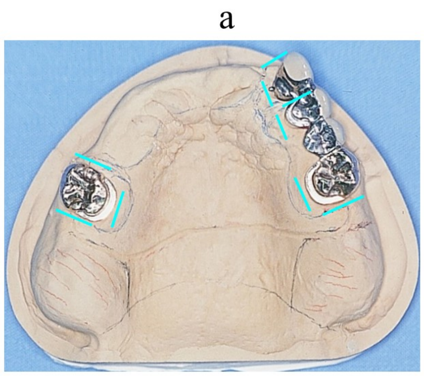
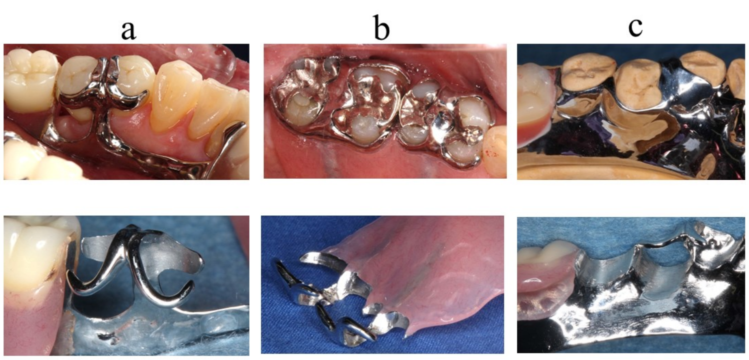


Figure 5

Figure 6

Figure 7

Figure 8



TABLES

Table 1

	Guiding planes
McCracken's [6] Stewart's [7]	The direction of placement or removal of the denture (path of insertion, path of placem