

## Evaluation of a New Intraoral Paralleling Device for Creating Guiding Planes: A Pilot Study

Alexandre Luiz Souto Borges, DDS, MsC, PhD; Alessandra Bühler Borges, DDS, MsC, PhD; Eduardo Shigueyuki Uemura, DDS, MsC, PhD; Tarcisio José de Arruda Paes-Júnior, DDS, MsC, PhD; Rubens Nisie Tango, DDS, MsC, PhD; José Eduardo Junho de Araújo, DDS, PhD; Estevão Tomomitsu Kimpara, DDS, MsC, PhD

### Abstract

**Aim:** The aim of the study was to assess the accuracy of a new intraoral paralleling device for creating proximal guiding planes for removable partial dental prostheses.

**Methods and Materials:** Thirty gypsum casts were divided into two groups in which the proximal surfaces of selected teeth were prepared using either a surveying device (Group 1) or the new ParalAB paralleling device (Group 2). In each cast guiding planes were prepared on the distal surface of the maxillary left canine (A), on the mesial and distal surfaces of the maxillary left second molar (B and C), and on the distal surface of the maxillary right canine (D). Each prepared surface formed an angle related to the occlusal plane that was measured five times and averaged by one operator using a tridimensional coordinate machine.

**Results:** The mean guiding plane angles ( $\pm$  standard deviation) for the prepared surfaces were A=91.82° ( $\pm$ 0.48°), B=90.47° ( $\pm$ 0.47°), C=90.21° ( $\pm$ 0.76°), and D=90.50° ( $\pm$ 0.73°) for the dental surveyor (Group 1) and A=92.18° ( $\pm$ 0.87°), B=90.90° ( $\pm$ 0.85°), C=90.07° ( $\pm$ 0.92°), and D=90.66° ( $\pm$ 0.76°) for the ParalAB paralleling device (Group 2). A two-way ANOVA, Tukey's, and Levène's tests (at  $p < 0.05$ ) revealed statistically significant differences among surfaces prepared by both groups and that one surface



(A in Group 2) was more parallel to the path of insertion than the other surfaces.

**Conclusions:** The ParalAB device was able to prepare parallel surfaces and despite significant difference between groups, the ParalAB presented a small deviation from absolute parallelism and can be considered a valid method to transfer guide plans in the fabrication of removable partial dentures.

**Clinical Significance:** The preparation of suitable guiding planes on abutment teeth during the fabrication of removable partial dentures is dependent on the ability of the operator and requires considerable chair time. When multiple

teeth are involved, achieving parallelism between abutment surfaces can be technically challenging, especially in posterior regions of the mouth. The ParalAB prototype intraoral paralleling device can aid the clinician during the preparation of accurate guiding planes with a minimum degree of occlusal divergence.

**Keywords:** Guide plane, removable partial denture, path of insertion, intraoral surveyor

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## Introduction

The preparation of multiple and parallel tooth surfaces is a difficult task, especially when posterior teeth are involved. Gingival tissues limit the amount of exposed clinical crown, direct visualization is restricted, and interocclusal space is limited.<sup>1</sup> It is not uncommon for clinicians to perform oral rehabilitation involving a removable partial denture (RPD) without adequate planning, which can result in injury to the supporting tissues.<sup>2</sup> An important first step in treatment planning is to determine the location and angle of two or more vertical parallel surfaces (guiding planes) of abutment teeth to guide



the path of insertion and removal of an RPD.<sup>3</sup> The use of multiple parallel surfaces or guiding planes decreases the possibility of prosthesis dislodgment. Other functions of guiding planes include minimizing deep undercut zones and food entrapment, improving esthetics, and providing reciprocity for retentive arm clasps.<sup>2</sup> Despite their importance, these surfaces rarely occur naturally and must be prepared directly on the proximal surface of abutment teeth or restorative materials.<sup>4</sup>

Several methods and devices have been proposed to aid in obtaining an optimal taper of tooth preparations. Intraoral and extraoral parallelometers have been developed.<sup>5-8</sup> Some have been used only for directly verifying the parallelism of abutment teeth,<sup>9</sup> while others were designed for actual tooth preparation.<sup>10</sup> However, such methods and devices are rarely employed in the preparation of abutment teeth for removable prostheses. Nevertheless, they can be adapted for such use.

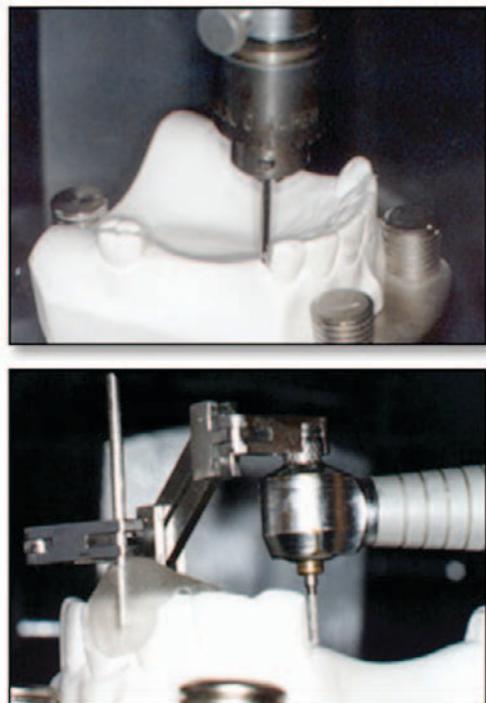
The freehand and pin-guided, plaque or device techniques rely exclusively on professional ability, are time consuming, and often necessitate multiple visits. That is why these devices are not more widely used by clinicians.<sup>11</sup> Intraoral and extraoral parallelometer devices are accurate and can be helpful during the preparation of guiding planes, but they are bulky and not readily available. Consequently, a prototype intraoral paralleling device (ParalAB) has been designed to allow clinicians to survey and prepare abutment teeth properly and then to verify parallelism of the prepared guiding planes. As a result, a prototype intraoral paralleling device (ParalAB) has been developed at the School of Dentistry of São José dos Campos at São Paulo State University in São José dos Campos, São Paulo, Brazil. The device allows clinicians to survey and prepare abutment teeth properly and then to verify parallelism of the prepared guiding planes.

## Methods and Materials

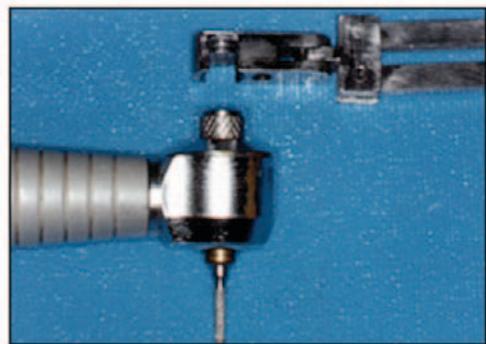
Thirty Type II gypsum master casts of a maxillary arch requiring a Kennedy Class III RPD were fabricated from a polyvinylsiloxane impression (Rodhorsil, Clássico Artigos Odontológicos Ind., São Paulo, Brazil.) and were divided into two groups (n=15). Specimens in Group 1 (control) were prepared using a conventional surveying device (Bio-Art Equipamentos Odontológicos, São

Carlos, São Paulo, Brazil), while the specimens in Group 2 were prepared using the prototype ParalAB intraoral device.

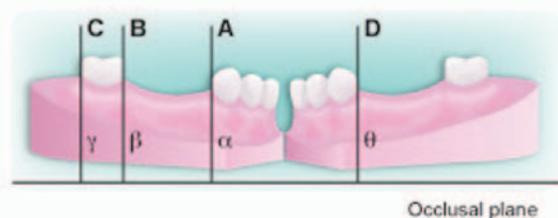
One operator made all of the tooth modifications and the path of insertion was determined as being



**Figure 1.** A. Guide plans preparations of control group. B. Guide plans preparation of ParalAB group.



**Figure 2.** Handpiece with magnetic bar to be attached in the locking arm of ParalAB.



**Figure 3.**

perpendicular to the occlusal plane (Roach's technique).<sup>4</sup> Guiding planes with 3 mm of vertical extension were prepared on the distal surfaces of the maxillary left canine (surface A), on the mesial (surface B) and distal (surface C) surfaces of the maxillary left first molar, and on the maxillary right canine (surface D) as shown in Figure 1.

The ParalAB device was locked according to the path of insertion, on the maxillary central incisors, with autopolymerizing acrylic resin (Clássico Artigos Odontológicos Ltda., São Paulo, Brazil)—Figure 1B illustrates how a magnetic bar was bonded to a handpiece using a cyanoacrylate-based adhesive in a handpiece and attached to the locking arm of the ParalAB. A KG #3097 cylindrical diamond bur (KG Sorensen, São Paulo, Brazil) was used to prepare the guiding planes (Figure 2).

Figure 3 represents a schematic drawing of maxillary casts in which the prepared surfaces (A, B, C, and D) created a corresponding defined angle with the occlusal plane ( $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\theta$ ).

The angles were measured with a three-dimensional coordinate machine (Strato 776, Mitutoyo Sul Americana, Suzano, São Paulo, Brazil). Five measurements were made of each prepared guiding plane surface, from which a mean angle and standard deviation were derived and reported in degrees.

## Results

The data were entered into a computer to calculate the mean values and standard deviations obtained for the control (Group 1) and the experimental (Group 2) groups, corresponding to the inclinations of the A, B, C, and D surfaces (see Table 1). The results were analyzed using a two-way ANOVA followed by a Tukey's test at the 0.05 significance level (Tables 2 and 3). The Levène's test was used to compare the variance of methods to evaluate the accuracy of repeated measures for each device.

## Discussion

The importance of proximal contour modifications for an RPD is well known. The importance of guiding planes has been well documented in the

**Table 1. Mean angles (in degrees) and standard deviations for surfaces A, B, C, and D for the two test groups.**

Surface (Angle)	Group 1			Group 2		
	Mean	90° Mean	Standard Deviation	Mean	90° Mean	Standard Deviation
A ( $\alpha$ )	91.82	1.82	0.48 a	92.18	2.18	0.87 b
B ( $\beta$ )	90.47	0.47	0.66 a	90.90	0.90	0.85 b
C ( $\gamma$ )	90.21	0.21	0.76 a	90.07	0.07	0.92 b
D ( $\theta$ )	90.50	0.59	0.73 a	90.66	0.95	0.76 b
Mean	90.75	0.75	0.66	90.95	1.02	0.85

Note: Results of Levene's test, where similar small letters indicate no significant difference ( $p < 0.05$ ).

**Table 2. Results of two-way ANOVA. ( $p < 0.05$ )**

	F	P
Device	7.48	0.0107*
Angle	21.02	0.0001*
Interaction	2.87	0.0410*

\*Significant difference at  $p < 0.05$ .

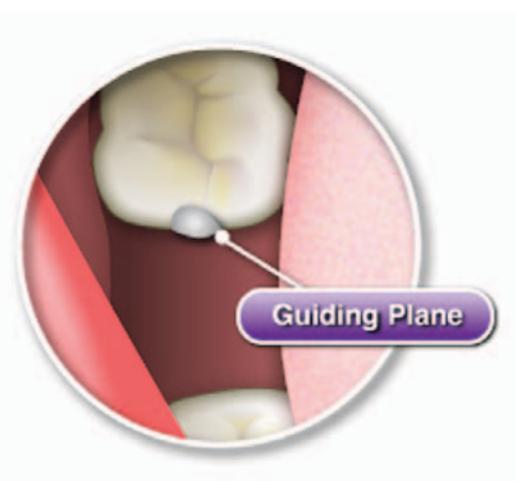
**Table 3. Results of the Tukey's test. (5%)**

Groups	Angle	Mean and SD	Homogeneous Group		
II	$\alpha$	92.18 ± 0.87	A		
I	$\alpha$	91.82 ± 0.48		B	
II	$\beta$	90.90 ± 0.85		B	C
II	$\theta$	90.66 ± 0.76		B	C
I	$\theta$	90.50 ± 0.73		B	C
I	$\beta$	90.47 ± 0.66		B	C
I	$\gamma$	90.21 ± 0.76			C
II	$\gamma$	90.07 ± 0.92			C

\*Similar capital letters indicate no significant difference.

literature as essential for successful treatment of removable prostheses using an RPD. While there are different techniques for transferring guiding planes from master die to mouth, it is very difficult to obtain perfect parallelism.<sup>12,13</sup> In this study, the ParalAB was used to survey, confirm, and prepare guiding planes on four tooth surfaces. To verify its accuracy, guide planes were prepared on master casts and the parallelism of the

surfaces was compared to those produced with a conventional dental surveyor. Several surfaces were chosen on different teeth to simulate and test the performance of the intraoral device in different clinical situations. A three-dimensional coordinate machine was used to measure surface inclinations. This method was efficient and easier to use than the methods used by Möllersten<sup>14</sup> and Moschèn et al.<sup>15</sup> to determinate parallelism.



The variance observed in both groups was small, as evidenced by the results of the Levène's test that revealed a great repeatability of the device (Table 1). Although the mean degree values obtained for the surfaces prepared by both devices were significantly different (Table 2), they were numerically very close and may not be clinically relevant.

The mean values listed in Table 3 are lower than those found by Möllersten,<sup>14</sup> who compared holes prepared by different intraoral devices ( $2.5 \pm 0.54^\circ$  by Paramax I,  $2.12 \pm 0.56^\circ$  by Paramax II,  $4.0 \pm 0.76^\circ$  by Prontostructor,  $3.48 \pm 0.81^\circ$  by PP-Instrument, and  $4.13 \pm 0.94^\circ$  by PRec-in-dent).

Comparing four different methods for transferring proximal grooves inside the mouth, Moschèn et al.<sup>15</sup> obtained mean values as follows:

1.  $3.15 \pm 1.67^\circ$  using the Parallel-A-Prep
2.  $4.37 \pm 2.12^\circ$  using free-hand preparation
3.  $4.10 \pm 1.62^\circ$  using preparation guided by pins
4.  $5.06 \pm 2.33^\circ$  using an extraoral parallelometer

In the present study, the inclinations were measured in relation to the occlusal plane. In order to compare the results of this study with other published reports, it was necessary to change the reference for the path of insertion ( $90^\circ$ ) as shown in Table 3. The greatest inclination surface prepared using the ParalAB was smaller than that found by Möllersten<sup>14</sup> and Moschèn et al.<sup>15</sup> despite the differences in methodology used.

The mechanical characteristics (degree of freedom) of a device determine its degree of accuracy. Since the ParalAB device has an

additional articulation compared to a conventional surveyor, it is less accurate.

Tables 2 and 3 show the values of both devices to be similar. In Group 1 the angles ranged from  $90^\circ$  to  $91.5^\circ$ , while in Group 2 using the ParalAB device they ranged from  $89^\circ$  to  $93^\circ$ . The mean value for Group 1 was smaller than  $1^\circ$  and for Group 2 the mean was smaller than  $1.5^\circ$  (Table 1). Both mean values are probably not clinically significant because of the inherent error associated with RPD framework fabrication. The freehand and guided planes techniques for transferring guiding planes from a cast to the mouth can require repeated impressions until master casts are produced that can be analyzed on a dental surveyor.<sup>16-19</sup> Such complexity may necessitate multiple clinical appointments and can generate mistakes in the cast position.<sup>9</sup> The graphite leads of the ParalAB makes surveying the abutment teeth inside the mouth possible, so a final impression may be made immediately following preparation of the various tooth surfaces.

In the past, several paralleling instruments have been developed for use primarily in parallel pin techniques,<sup>5-8,19-21</sup> but all have fallen into disuse because of the difficulties in positioning the instruments and their limited scope. The limited range of three-dimensional movements required during tooth preparation, an unwieldy size, an inadequate control of parallelism, and a negative time-cost factor<sup>10</sup> are additional disadvantages of these devices. The intraoral devices Paramax II, PRec-in-dent, and Parallel-A-Prep were reported in the literature for their use in preparing guide planes.<sup>22</sup> These devices varied in size, shape, bulk, and application form, allowing vertical movements suitable for preparing guiding planes, but they are difficult to obtain.

The ParalAB device has the following advantages:

- A small size
- Freedom of movement in three axes of rotation
- A working range of both sides of the mouth to achieve crossarch parallelism
- Easy fixation in the oral cavity
- Easy transference of the orientation of guiding planes from a cast to the oral cavity
- Ability to survey inside the mouth
- Ability to facilitate the recontouring of tooth abutments for RPD
- Savings of time in the dental laboratory

Nonetheless, due to the great variety of the partially edentulous patients and of the quality of the abutment teeth, developing an intraoral device for all types of clinical situations is very difficult. Therefore, the ParalAB device requires further evaluation by clinicians in different clinical situations to assess its practicality and establish its range and ease of use.

## Conclusions

Within the limitations of this study, the following conclusions were drawn:

1. The inclination of abutment teeth obtained with the ParalAB device were significantly different (greater) than the values obtained with a dental surveyor.
2. The ParalAB device can be transferred to the mouth to obtain guiding plane angles comparable to those obtained extraorally with a surveyor and offer a better alternative to “freehand” guiding plane preparation.

## Clinical Significance

The preparation of suitable guiding planes on abutment teeth during the fabrication of removable partial dentures is dependent on the ability of the operator and requires considerable chair time. When multiple teeth are involved, achieving parallelism between abutment surfaces can be technically challenging, especially in posterior regions of the mouth. The ParalAB prototype intraoral paralleling device can aid the clinician during the preparation of accurate guiding planes with a minimum degree of occlusal divergence.

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## About the Authors

### Alexandre Luiz Souto Borges, DDS, MsC, PhD (Corresponding Author)



Dr. Borges is an assistant professor in the Department of Dental Materials and Prosthodontics of the School of Dentistry of São José dos Campos at São Paulo State University–UNESP in São José dos Campos, São Paulo, Brazil.

e-mail: [aleborges@fosjc.unesp.br](mailto:aleborges@fosjc.unesp.br)

### Alessandra Bühler Borges, DDS, MsC, PhD



Dr. Borges is an assistant professor in the Department of Restorative Dentistry of the School of Dentistry of São José dos Campos at São Paulo State University–UNESP in São José dos Campos, São Paulo, Brazil.

e-mail: [alessandra@fosjc.unesp.br](mailto:alessandra@fosjc.unesp.br)

### Eduardo Shigueyuki Uemura, DDS, MsC, PhD



Dr. Uemura is an assistant professor in the Department of Dental Materials and Prosthodontics of the School of Dentistry of São José dos Campos at São Paulo State University–UNESP in São José dos Campos, São Paulo, Brazil.

e-mail: [esuemura@uol.com.br](mailto:esuemura@uol.com.br)

### Tarcisio José de Arruda Paes-Júnior, DDS, MsC, PhD



Dr. Paes-Júnior is an assistant professor in the Department of Dental Materials and Prosthodontics of the School of Dentistry of São José dos Campos at São Paulo State University–UNESP in São José dos Campos, São Paulo, Brazil.

e-mail: [tarcisio@fosjc.unesp.br](mailto:tarcisio@fosjc.unesp.br)

### Rubens Nisie Tango, DDS, MsC, PhD



Dr. Tango is an assistant professor in the Department of Dental Materials and Prosthodontics of the School of Dentistry of São José dos Campos at São Paulo State University–UNESP in São José dos Campos, São Paulo, Brazil.

e-mail: [tango@fosjc.unesp.br](mailto:tango@fosjc.unesp.br)

### José Eduardo Junho de Araújo, DDS, PhD



Dr. Araújo is a professor and chair of the Department of Dental Materials and Prosthodontics of the School of Dentistry of São José dos Campos at São Paulo State University–UNESP in São José dos Campos, São Paulo, Brazil.

e-mail: [posgrad@fosjc.unesp.br](mailto:posgrad@fosjc.unesp.br)

### Estevão Tomomitsu Kimpara, DDS, MsC, PhD



Dr. Kimpara is a professor in the Department of Dental Materials and Prosthodontics of the School of Dentistry of São José dos Campos at São Paulo State University–UNESP in São José dos Campos, São Paulo, Brazil.

e-mail: [estevao@fosjc.unesp.br](mailto:estevao@fosjc.unesp.br)