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Planning and RPD mouth preparation by Brazilian dentists in digital dentistry scenario

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Aim: This study aimed to verify the percentage of Brazilian dentists who plan and prepare partially edentulous mouths to receive RPDs. Comparisons between Brazilian dental laboratories working with conventional and digital technology (DT) were also performed. **Methods:** A questionnaire hosted on the Google Forms platform was sent to dental technicians, from all Brazilian regions, who work with RPD framework manufacturers to assess: (1) the technological level of the laboratory, (2) the percentage of master casts received with RPD-specific mouth preparation, and (3) the percentage of work request with RPD design sent by dentists to a laboratory. A Chi-square test was applied to analyze data and a significance level of 5% was adopted. A total of 158 dental technicians participated in this study. **Results:** A total of 3371 master casts were evaluated by dental technicians, including all Kennedy classifications. However, only 607 (18.01%) of them had RPD-specific mouth preparation. Dental technicians working with DT present more master casts with mouth preparation (p=0.001) and work requests (p=0.001) compared to those who use conventional technology. In addition, no difference was noted in the quality of RPD-specific mouth preparations between master casts received by technicians working with conventional and DT (p>0.05). **Conclusion:** Most Brazilian dentists (81.99%) do not perform RPD-specific mouth preparation. Besides, dental technicians who work with DT receive more master casts of higher quality, with mouth preparation, and work requests compared to those who do not.

Keywords: Denture, partial, removable. Technology. Dentistry.

Introduction

Tooth loss is a global problem[1] common in adults of different age groups. Nevertheless, it is more prevalent in older people[2] with low family income[3]. Developing countries have higher rates of edentulism[4], and it is estimated that in Brazil, one-fifth of the elderly population is partially edentulous in both dental arches[4]. In this scenario, removable partial dentures (RPD) is the therapy elected in most clinical cases as a form of oral rehabilitation of a partially edentulous population because it is conservative, has a good cost-benefit ratio, and represents a quick solution for patients[5].

Conventionally, the manufacturing method for RPD frameworks is based on the lost wax technique[5]. However, according to some authors, this method is closely associated with processing and adaptation failures[5,6]. Nonetheless, advances in computer-aided design and computer-aided manufacturing (CAD/CAM) technology have allowed the RPD process to be included in digital dentistry, improving the accuracy of its framework[7,8] and reducing the number of adjustments and work time[8]. Despite that, a high rate of RPD failure is still observed, mainly due to a lack of planning[9].

RPDs diagnosis and planning remain the responsibility of the dentist[10,11]. These professionals must perform a careful clinical and radiographic examination, obtain high-quality study casts, and determine the parallelism between the support teeth to obtain an adequate insertion and removal trajectory of the RPD[12]. Furthermore, the height of countour and the retentive areas of the supporting teeth must be analyzed to eliminate possible aesthetic damage associated with the location of the metal[12,13]. Finally, the correct location of the rest preparations is essential for transmitting forces along the axis of the abutment teeth[12-14], reducing torque and preventing tooth mobility[12,14]. Thus, for the success of oral rehabilitation with RPD, dentists must plan the RPD design and clinically prepare the supporting teeth[5] by making rest preparations, guide planes, and obtaining sufficient retention[12].

Although dentistry teaching in Brazil includes the discipline of RPD[15,16], dentists commonly neglect or delegate prosthesis planning to dental prosthesis technicians who do not have enough knowledge to determine the best RPD design[17] and do not prepare the mouth to receive such prosthesis, negatively affecting treatment success. It is important to note that despite technological advances that have allowed the processing of RPDs with greater adaptation of its components to the support structures and made the workflow faster[8], the clinical steps of mouth preparation remain the same. Thus, it is reasonable to suppose that using digital technology (DT) for RPD construction, clinicians may feel even more comfortable to continue delegating the RPD planning role to the dental technician. Nevertheless, there is no study on this topic.

Therefore, this study aimed to verify the percentage of dentists who plan and carry out RPD-specific mouth preparation in Brazil, through a survey conducted with dental technicians working with different technological levels. In addition, the quality of master casts with RPD-specific mouth preparations and planning design sent to dental

technicians who work with DT for RPD framework manufacture was compared with those casts sent to laboratories that use conventional technology. Thus, the research working hypothesis was that there is a difference in the percentage of dentists who plan and carry out RPD-specific mouth preparation through master casts evaluation sent to dental technicians who work with DT for RPD framework manufacture and those who use conventional technology.

Material and Methods

This observational study was approved by the Ethics Committee at Piracicaba Dental School, University of Campinas, São Paulo, Brazil (registration number: 69841223.0.0000.5418). Study participation was voluntary, with participants providing digital consent before enrollment.

Master casts of partially dentate individuals were analyzed by dental technicians divided into two groups: *(1)* dental technicians who work with DT (experimental, n = 1028), and *(2)* dental technicians who work with conventional technology (control, n = 2343). According to a sample size calculation, based on a previous study[18] (power of 0.8 and significance level of 0.05), a minimum of 1023 master casts should be evaluated by each technician group. However, there was no minimum number of casts stipulated for each laboratory. Instead, each dental laboratory should evaluate master casts according to their demand, for one month. Thus, the total number of master casts analyzed by laboratories with and without DT should be at least 1023 for each.

Dental technicians from all Brazilian regions that manufacture RPDs framework were contacted through the internet, specifically digital media WhatsApp Messenger (WhatsApp LLC, Meta, Santa Clara, CA, USA), and received an invitation to participate in this study. Therefore, to be included in this study, dental technicians should have internet access besides working in the manufacture of RPD frameworks. Clearly, dental technicians who do not manufacture RPD frameworks were excluded.

The dental technicians received and answered a questionnaire (Table 1) hosted on a Google Forms platform (Google LLC, Mountain View, CA, USA), which was available for one month. Technicians who accepted the invitation to participate, digitally signed an informed consent form to gain access to the questionnaire.

The questionnaire (Table 1) was divided into four sections: (1) the technological level and the region of Brazil to which it belongs, (2) the presence and quality of the RPD-specific mouth preparation on the master cast, and finally, (3) covered information regarding the work request and design of the RPD framework.

Table 1. Questionnaire sent to Brazilian dental technicians who manufacture RPD frameworks.

Technological level
1. Does the dental technician use digital technology (scanning, digital surveyor, and fast prototyping) to manufacture RPD frameworks? Yes or No?
2. Does the technician plan to migrate to digital technology in the near future (6 months or a year)? Yes or No?

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3. Which Brazilian region are you located in?
a. North
b. Northeast
c. Midwest
d. Southeast
e. South
General considerations of master casts
1. Which material was used to manufacture the master casts?
a. Type II dental stone
b. Type III dental stone
c. Type IV dental stone
2. Were there positive and/or negative air bubbles in the seating areas of the RPD framework? Yes or No?
3. Were there positive and/or negative air bubbles in the rest areas of the RPD framework? Yes or No?
4. Which Kennedy classification is being analyzed?
a. Class I
b. Class II
c. Class III
d. Class IV
RPD-specific mouth preparation
1. The RPD-specific mouth preparation was made? Present or Absent?
2. The RPD-specific mouth preparation is correctly distributed? Yes or No?
3. How is the RPD-specific mouth preparation? Good or Poor?
Work requisition and RPD design
1. Did the dentist send you the written description of the RPD framework? Yes, No, or Sent, but incorrect?
2. Did the dentist send you the RPD design? Yes, No, or Sent, but incorrect?

RPD = Removable partial denture.

Before answering the questionnaire, each technician received, via WhatsApp, detailed instructions on the criteria to be used to evaluate each cast. The researcher was available to clarify any doubts during all data collection period. Initially, the technician should answer about the technological level and Brazilian region in which it was located. Following, the characteristics observed in the master cast (i.e. type of dental stone used, presence of air bubbles, and Kennedy classification of the case) were recorded. Once the digital workflow allows the technician to manufacture RPD structures using the "stl" file obtained by intraoral scanning or bench scanning of the master cast, the technician was instructed to evaluate the file following the pattern described for the physical master cast. Therefore, to assess the master casts or "stl" files, technicians followed the subsequent criteria:

1. *presence and location of RPD-specific mouth preparation:* master casts originating from dental arches classified as Kennedy Class III and IV, should present rest preparations located on the marginal ridges adjacent to the prosthetic spaces. Meanwhile, Kennedy Class I and II master casts should present rest preparations for the mesial marginal ridges opposite the prosthetic space[18]. Master casts that did not present the distribution as described or without mouth preparation for RPD were classified as absent. In contrast, when master casts contained specific mouth preparations for RPD and corrected located, it was classified as present.

2. *shape of rest preparations*: dental technicians were instructed to analyze whether the occlusal rest preparations had a triangle form with rounded angles, the apex facing the center of the crown, with the width of the isthmus equal to 1/3 of the distance between the buccal and lingual cusps. Besides, the mesiodistal direction should extend from 1/3 to 1/2 of the width of the tooth[19], and its depth should be between 1.5 and 2.0mm. Finally, the axial walls of rests must be expulsive and the pulp wall flat with an inclination to the center of the tooth less than 90^0 [19]. In turn, cingulum rest preparations should be in the shape of an inverted "V", being concave in the buccolingual direction and convex in the mesiodistal direction[18]. If one of the rests did not present the shape as above described, the technician should classify the RPD-specific mouth preparation as poor. However, if rests presented the appropriate shape, they were classified as good.

3. *requesting work from the laboratory:* it was evaluated according to the written description of the prosthesis framework, as well as its design. The Kennedy classification[19] should be described, and the type of extra coronary retainer clearly identified, along with its components (name of clasps, opposition arms, and minor connectors)[18]. In addition, the major connector and the saddle must be drawn and described in the planning sent by the dentist[18]. If the written description or framework drawing was not sent or sent incomplete, the technicians were instructed to consider it as absent.

Statistical analysis

The SPSS Statistics software (Version 25.0, IBM Corporation, Chicago, IL, USA) was used for statistical analyses and a significance level of 5% was adopted. The chi-square test was applied to analyze the data.

Results

Although sample size estimated that 1023 master casts for each dental laboratory (with or without DT) were enough to show significant differences, a total of 3371 master casts were evaluated, being 102 analyzed by technicians working in laboratories with DT and 2343 by those working in conventional laboratories. The number of master casts evaluated by each dental technician was not computed. Among the total, Kennedy class III was the most prevalent (34%), followed by Kennedy class II (32.66%), Kennedy class I (29.75%), and finally, Kennedy class IV (3.59%). Furthermore, most of the master casts (69,53%) were sent to dental technicians who use conventional technology to manufacture the RPD frameworks, while 30.47% were sent to technicians who work with DT.

To evaluate the master casts, 242 dental technicians from all Brazilian regions were invited to participate in this study. However, 158 agreed to participate and answered the questionnaire, being 14 dental technicians from the Brazilian Northern region (8.86%), 57 from the Northeast (36.08%), 16 from the Midwest (10.13%), 44 from the Southeast (27.85%), and finally, 27 from the South of Brazil (17.09%). Of the total number of participating technicians, 68.99% use conventional technology (n = 109) to process RPD frameworks, while 31.01% work with DT (n = 49). In addition, dental technicians migrated to DT around 2.3 years ago (±1.32). On the other hand, technicians who do not use DT have been working with the conventional technique for around 16.07 years (±7.82).

Table 2 shows the distribution of material used to make the master casts. It was observed that dental technicians working with or without DT and received the majority of master casts produced with type IV dental stones (82.93% and 84,82%, respectively). Despite working with DT, only a small percentage (11.09%) of technicians received "stl" archives obtained from intra-oral scanning. Considering only physical master casts, it was observed that technicians who work with DT received master casts with fewer air bubbles in the seating areas of the future framework and in the rest preparations when compared with those who use conventional technology (p=0.001). Almost twice as many dentists sent master casts with air bubbles to technicians who use conventional technology (6.23%) when compared to those who work with DT (3.5%) (p=0.001). Highlighting, dental technicians who use conventional technology received more Kennedy class II with air bubbles in the seating areas of the future framework and in the rest preparations (p=0.008) when comparing dental technicians that work with DT.

Table 2. Distribution (%) of master casts sent to Brazilian dental laboratories according to its Kennedy's classification and construction material.

Kennedy Classification	Materials	Brazilian dental laboratories	
		CT (%)	DT (%)
Class I	Type III Dental Stone	26.15	7.17
	Type IV Dental Stone	73.85	85.34
	Intra-oral scanning	0	7.49
Class II	Type III Dental Stone	14.55	3.77
	Type IV Dental Stone	85.45	85.22
	Intra-oral scanning	0	11.01
Class III	Type III Dental Stone	12.3	2.93
	Type IV Dental Stone	87.7	84.17
	Intra-oral scanning	0	12.9
Class IV	Type III Dental Stone	8.14	0
	Type IV Dental Stone	91.86	77.14
	Intra-oral scanning	0	22.86

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Total	Type III Dental Stone	17.07	4.09
	Type IV Dental Stone	82.93	84.82
	Intra-oral scanning	0	11.09

CT = Conventional technology; DT = Digital technology

RPD-specific mouth preparation

Regardless the technological level, among the 3371 master casts analyzed by dental technicians, only 607 of them had RPD-specific mouth preparation. Of this total, 222 master casts were sent to dental technicians who use DT, while 385 master casts to those who use conventional technology. Table 3 demonstrates that dental technicians working with DT received more master casts (p=0.001) containing RPD-specific mouth preparation compared to those with conventional technology. Regarding the quality of RPD-specific mouth preparations carried out by dentists, no difference was noted between master casts sent to dental technicians with or without DT (p>0.05) (Table 3).

Table 3. Comparison of RPD-specific mouth preparation between master casts sent to Brazilian dental laboratories with and without DT.

Specific Mouth Preparation	Brazilian dental technicians		p-value
	CT (%)	DT (%)	
Present	16.45	21.65	0.001*
Absent	83.55	78.35	
Good	64.57	59.38	0.114
Poor	35.43	40.62	

CT = Conventional technology; DT = Digital technology
*chi-square test

Requesting work from the laboratory

Considering the framework design, it was observed that 94.26% of dental technicians who work with DT and 92.87% of those who work with conventional technology do not receive any kind of framework design (p>0.05) (Table 4). On the other hand, technicians who work with DT received more written descriptions of the RPD framework (p = 0.001) (Table 4), especially for classes I, II, and III (p=0.001; p=0.003; p=0.001, respectively), when compared with those who work with conventional technology.

Table 4. Comparisons of RPDs framework design, written description between Brazilian dental laboratories with and without DT.

	Brazilian dental laboratories		p-value
	CT (%)	DT (%)	
RPD framework design			
Presence	7.13	5.74	0.138
Absence	92.87	94.26	
Written description			
Presence	24.11	35.31	0.001*
Absence	75.89	64.69	

CT = Conventional technology; DT = Digital technology
*chi-square test

Discussion

This study showed that the percentage of Brazilian dentists who plan and carry out specific mouth preparation of RPDs is still low compared to the previous national studies[18,20]. Besides, dental technicians who work with DT have received the highest percentage of master casts containing mouth preparation and written descriptions of RPD framework. Based on these findings, the working hypothesis was confirmed, with dental technicians working with DT receiving a higher percentage of master casts with RPD preparation and written description of the RPD framework design.

Considering the RPD-specific mouth preparation, our data agree with previous studies[18,20], which showed that most dentists do not prepare the mouth to receive RPD. According to Farias Neto et al.[15] (2010), this occurs because most dentists are unaware of all the steps involved in the manufacture of RPD, and this has been observed since undergraduate dentistry education[15]. Among these steps, dentists do not know how to properly use a surveyor, delegating this function to the dental technician and consequently compromising the RPD-specific mouth preparation[18,21]. Therefore, a minor portion of dentists may understand the importance of specific mouth preparation for the preservation of supporting frameworks and long-term treatment success[12].

The digital flow for manufacturing the RPDs framework in this study was carried out through intra-oral scanning or bench scanning of the master cast. Among master casts with specific mouth preparation, technicians working with DT received a higher percentage of master casts with mouth preparation. Dentists may associate the RPD-specific mouth preparation with the fact that this prosthesis manufactured by the digital method may result in prostheses with better accuracy and fewer clinical adjustments[8]. On the other hand, when analyzing the quality of mouth preparation, dental technicians who work with DT receive master casts with lower quality, highlighting the lack of knowledge of the dentist to properly prepare the patient to be rehabilitated with RPDs[15,16].

In addition to the absence of RPD-specific mouth preparation, few dentists carry out planning through the design of the RPD framework. Despite technicians working with DT received a higher percentage of master casts with RPD written description (35.31%), this percentage remains low when compared to previous studies[18,20] and reveals that nowadays, the responsibility for planning is still transferred to dental technicians. Although this practice is not recommended because technical professionals do not have adequate knowledge to carry out this stage of treatment[17], which results in high variability in the design/planning of RPD frameworks[22], our finding agrees with several authors[12,18,20,21] who also observed such role transference to technicians. This transfer of responsibility is observed in international[14,22,23] and national[11,18,20,21] scenarios, and it is particularly alarming in Brazil, considering that RPDs are the prostheses in greatest demand[4]. Therefore, it is necessary to implement and restructure RPD teaching by increasing the practical workload and improving the integration between theory and practice[16]. Furthermore, dentists must seek continuing education courses, which allow them to update themselves[16], reinforcing the importance of carrying out all clinical steps and adequate planning for rehabilitation with RPDs[15].

Surveying is the stage of RPDs planning more neglected by dentists[16]. The surveying procedure aims to determine the path insertion of the future prosthesis, also locate areas of interference and the need for guide plans, determine the survey line, and identify retentive areas for placing the retentive terminal of the clasps being usually made with an analog surveyor [24]. However, considering the digital workflow, the survey can be conducted using specific software[25], which automatically delineates a survey line that can be adjusted based on the guidance of the digital cast[26], which may reduce execution time and potential errors. Despite being promising, there are no studies on the accuracy of digital versus conventional survey.

Regarding the characteristics of the master casts, most dentists sent master casts processed with type IV dental stone and with a low percentage of air bubbles. This finding corroborates the study by Dantas et al.[20] (2011), in which 58.3% of the master casts were made with type IV dental stone, a material recommended for making RPD frameworks. Considering the presence of positive or negative air bubbles in the prosthesis seating region and in the rest preparations, the percentage of master casts sent to both technicians who use DT and conventional technology was low (3.5% and 6.23%, respectively). However, technicians using DT received master casts with a lower percentage of air bubbles, mainly in Kennedy class II. This may be related to the fact that 11.09% of master casts received by dental technicians working with DT were through intra-oral scanning. This technique presents greater accuracy of edentulous arches when compared to the technique of printing and making dental casts[27], and similar accuracy when it comes to hard tissues[28].

The number of Brazilian technicians who use DT is still lower compared to those who use conventional technology, which may limit our research. The high cost of the equipment and software necessary to perform prosthetics using the digital method may explain such data. Furthermore, the number of participants from each Brazilian state was heterogeneous, compromising comparisons between them. In addition,

it was not possible to calibrate all technicians who evaluate the master casts, which can also be a limitation of our study. However, the researchers carefully instructed all technicians on how to evaluate each cast to improve the veracity of the results. It is also important to point out that there is no instrument to verify the mouth preparation and the quality of master casts sent to dental laboratories. Thus, depite our questionnaire not being validated in the literature, it was based on previous studies[18,19], which help to support our data. Therefore, our findings are important to show how RPDs are being planning and processed by Brazilian dentists and whether DT is influencing such behaviours. Thus, future studies should be carried out to validate an instrument to generate more reliable data.

Based on the findings of this study, it can be concluded that most Brazilian dentists (81.99%) do not perform RPD-specific mouth preparation and RPD planning is still being delegated to dental technicians, as it was seen in the past. Among those who plan, it was observed that a greater percentage (35.31%) of them work in partnership with laboratories that use DT to manufacture RPDs. Finally, 96.5% of master casts sent to laboratories with DT had good quality.

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Conflict of Interest

The authors have no conflict of interest to disclose.

Data availability

Datasets related to this article will be available to the corresponding author upon request.

Authors Contribution

Guilherme Fantini Ferreira: Conceptualization, methodology, formal analysis, investigation, resources, data curation, writing - original draft, writing - review & editing, visualization. **Nadine Zumsteen:** Conceptualization, methodology, formal analysis, investigation, resources, data curation. **Lorena Tavares Gama:** Conceptualization, methodology, formal analysis, investigation, resources, data curation, writing - original draft; writing - review & editing, visualization. **Renata Cunha Matheus Rodrigues Garcia:** Conceptualization, methodology, formal analysis, investigation, resources, data curation, writing - original draft; writing - review & editing, visualization, project administration.

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