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Editorial

Dear Researcher,

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Mário dos Anjos Neto Filho
Editor-in-Chief JSCD

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AESTHETIC REHABILITATION OF THE "GUMMY SMILE" ASSOCIATED TO VIRTUAL PLANNING WITH "DIGITAL SMILE DESIGN" - DSD

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ABSTRACT

The smile has a great importance in the life of an individual, not only for aesthetic reasons, but also for psychological, social, emotional relationships and health reasons. Excessive gingival exposure during smiling - the gummy smile - is currently being considered as a factor unaesthetic before professionals and layman. There are several factors responsible for the gummy smile, among these the most common are altered passive eruption and vertical growth of the maxilla. For the implementation of a differentiated dental treatment seeks increasingly interact with virtual and photographic methods. Thus, the Digital Smile Design (DSD) is a virtual tool based on intra and extra oral photos, which aims to provide a preview of the treatment, as well as a multidisciplinary communication. In periodontology there are several surgical techniques designed to correct the gummy smile, all when well indicated feature a satisfactory aesthetic result. This study aims to demonstrate through a case report, the use of a virtual tool (DSD) used in planning a rehabilitation gingival aesthetics. This method is a viable alternative for the promotion of an aesthetically pleasing smile.

KEYWORDS: Periodontics, gum surgery, virtual planning.

1. INTRODUCTION

The aesthetic has always been seen as synonymous with beauty. The face, being the body part that attracts much attention in the first instance, must present nice morphological features. The constant quest for a beautiful smile is currently one of the reasons responsible for the high demand of the population for aesthetic dental treatment[1]. The reference standard of a smile considered ideal, is usually formed through the harmonious relationship between teeth, soft tissue and facial features[2]. The latest concept approached by visagism shows a concern relating to the facial features with the shape of the teeth and hence the type of the patient's smile. Thus, based on this concept, the kind of the smile might be able to indicate or suggest the type of personality of an individual[3].

There are several ways to measure and classify the type of smile. However, the most followed by most professionals, is employed by Garber & Salama (1996)[4]. In this way of evaluation, we use the position of the lower edge of the upper lip relative to the gingival margin of the maxillary anterior teeth to classify the type of smile. The features presented by gum tissues and diversity in patients occur due to genetic reasons[5]. In a recent literature review, Esfahrood *et al.* (2013)[6], highlight the different periodontal biotypes, respond differently to inflammation, surgical and restorative treatment and so it is very important to identify the tissue biotypes before the aesthetic treatment.

A frequent complaint among patients seeking dental office is currently dissatisfaction with the smile due to gummy smile, characterized by too much exposure to a range of gum (greater than 3 mm) in apiculture coronal direction during the act of smiling[7].

The etiology of the gummy smile is extremely important to determine the ideal type of treatment for different cases, being essential to the achievement of accurate anamnesis and clinical and radiographic examination[8]. The hyperactivity of the elevator muscles of the upper lip, dentoalveolar extrusion, short upper lip, excessive vertical maxillary growth, altered passive eruption, gingival hyperplasia drug are the main causative agents in the literature[9].

Dentistry recently gained a form of assistance in planning aesthetic, and can be applied with the periodontal surgical planning. This innovative technique, called Digital Smile Design (DSD) consists in using digital images of high quality, via digital photographs. Recently, Coachman *et al.* (2012)[10] presented the DSD that it is the use of images worked in PowerPoint or

Keynote software, able to help in the virtual dental plan. This technique consists of inserting lines and drawings on digital facial photos and intra patient's mouth. This procedure helps in the analysis, documentation and communication between professional and patient, encouraging understanding and visualization of the proposed treatment. Thus, after identifying the problem and correct virtual diagnosis to implement appropriate for case resolution technique.

Therefore, this work aims to present a Case Report in which the virtual planning was used as an aid in periodontal surgical planning in order to correct the gummy smile.

2. CASE REPORT

Patient with initial "S.S.D.B.", female, 25 years old, came to the dental office of University Paranaense - UNIPAR, complaining of dissatisfaction with your smile due to overexposure of the gingival tissue during the act of smiling. Clinical history was taken and it was found that the patient had no systemic involvement. Moreover periapical and panoramic radiographs, facial analyzes were performed, detecting the type of high smile, also called "gummy smile" (Figure 1).

Figure 1. Patient with "Gingival Smile".

We proceeded to the clinical examination and noted that the patient had short clinical crowns with large amount of attached gingiva: a gingival phenotype plan / thicker with gingival asymmetry. After clinical and periodontal evaluation, diagnosis passive rash associated with altered growth vertical of the maxilla (Figure 2).

The treatment proposed for the resolution of this case was periodontal surgery using the technique of internal bezel without osteotomy. Clinically there was a large gingival inflammation due to accumulation of dental plaque and calculus, which led to the need for adaptation of the oral environment through scaling and prophylaxis prior to esthetic periodontal surgery.

Figure 2. Short clinical crowns, gingival phenotype plan / thicker; gingival asymmetry, altered passive eruption accompanied by vertical growth of the maxilla.

The planning of the event was carried out with the aid of intra and extra oral photographs of the initial patient in the virtual planning technique DSD (Figure 3), with the goal of providing a better understanding and preoperative visualization of the proposed treatment.

Figure 3. Virtual planning of the technique DSD.

After obtaining the information of the characteristics of the patient's smile, through the DSD, the diagnostic waxing the surface of the working model was developed. Subsequently, we performed a mock-up, playing the final surgical outcome prior to surgery, providing patients with an accurate view of the proposed treatment, interacting with professionals. In this technique, via waxing of the model, we saw the amount of gum that will to be removed. A wall is made of silicone on the waxed model, and through it, a self-curing bisacrylic resin (Protemp 3M) who rebuilt the tooth structure, thus having a direct simulation of the patient's mouth. During the two days, the patient remained with the mock-up having the opportunity to evaluate the proposed design (Figure 4).

With the previously waxed model, a surgical guide was prepared, with the purpose of assisting in surgery, providing a reference to the incisions and following the gingival contour proposed. In view of the patient satisfaction with the simulation, has begun the surgical procedure.

Starting from the selected surgical technique followed the procedure with infiltrative anesthesia in the region of molars, premolars and incisors with complement on palate.

Figure 4. Mock-up in position.

Then, took place the trans-sulcular survey in order to ascertain the location of the bone crest and the realization of the bleeding for reference and comparison with previously manufactured surgical guide points.

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With the surgical guide into position the incision with the blade 15C was performed at 45° to the long axis of the tooth at the incisal to apical direction, starting from the right first molar to the left watching the drawing (Figure 5).

Figure 6. After removal of the collar gum.

After, an intra-sulcular incision and removal of the gingival collar we performed with a curette Mac Call 17-18. Subsequently a total flap was folded to check bone architecture, restoring the limits of biological space, followed by simple suture interpapillary, guaranteeing greater stability, approximation and coaptation of the tissue (Figure 6).

At the end of the procedure the patient was oriented about the care during the postoperative period. Was prescribed: antibiotic (amoxicillin 500 mg, 1 capsule every 8 hours for 7 days), antiinflammatory (nimesulide 100 mg, 1 tablet every 12 hours for 5 days), analgesics (acetaminophen 750 mg, 1 tablet every 8 hours for 3 days) plus a chemical control (0.12% chlorhexidine digluconate, 2 times a day for 7 days).
After 7 days, the patient returned to the clinic for suture removal and evaluation of post-operative healing process, according to Figure 7.

Figure 7. Suture removal after 7 days

The patient returned for follow-up 40 days after surgery, which underwent a restorative treatment for closure of diastema (figures - 8A and 8B).

Figure 8. A: anterior and posterior restorations; **B:** final appearance.

3. DISCUSSION

The dental professional must submit a multidisciplinary knowledge to perform aesthetic procedures. The current periodontics has great contribution in planning and aesthetic association of dental specialties with photographic capabilities and computing represents an almost mandatory requirement for professionals involved with aesthetics. According Cairo *et al.* (2012)[11], the dentist must make a correct diagnosis and identification of possible etiologies of the patient's smile, evaluating quirks and ways of treatment.

Undoubtedly, during the aesthetic evaluation of the patient, the reference points described by Garber & Salama (1996)[4] are important to guide the aesthetic planning, as the incisal of the maxillary anterior teeth should follow the contour of the lower lip, the clinical crown the central incisors and canines have the same length, the length of the lateral incisors must be 1 or 2 mm shorter at the central and canines. Other information cited by Zanetti *et al*. (2007)[12] also deserve to be considered, for these authors, the complete harmony of the smiling also depends on the shape, texture and tooth and gum´s color as well as facial features such as facial contours, midline, labial line and interpupillary line.

Garber & Salama (1996)[4] classified four types of smiles as low, which is characterized by exposure of only 75% to less than the height of the clinical crown of the anterior superior teeth, the mean grin, which exposes the total height of the tooth along the interdental papillae or 75% of this, and high when the total height of the tooth is visualized and an amount of greater than 3 mm gingiva is exposed during smiling, which characterizes the so-called “gummy smile." These authors considered the exposure of the gingival margin of the maxillary incisors between 1-3 mm in the act of smiling as the standard more aesthetic smile. Based on this classification, the patients in this study had a high type of smile, and etiology of altered passive eruption it was excessive gingiva on the crown of the teeth, giving appearance of short teeth, associated with the vertical growth of the maxilla.

The knowledge and identification of gingival biotype represent an important stage for the correct diagnosis and treatment planning. The literature points to two gingival biotypes: flat/ thicker and dense fibrotic feature with less inequality between the buccal and interproximal gingival margin, with wide and thick gingiva and buccal massive bone contour related to teeth with square shape and high point of interproximal contact. Already the "thin/ festooned" biotype is characterized by a delicate gingival surface translucent appearance being that the papilla does not fill all the space of the interproximal niche, little thin gingiva and buccal bone contour, presence of fenestration and dehiscence related to teeth with triangular in shape and point of contact decreased in incisal or occlusal[13].

The fine/ festooned biotype gum tends to have an inflammatory response when subjected to physical trauma leading to the development of gingival recession. Already biotype plan/ thicker reacts to trauma with signs of inflammation and gengival[14] growth. The patient had gingival biotype plan / thicker supra-bony pockets.

Now, due to the established diagnosis and characteristics of the smile in question, it becomes easier to choose the type of proper technique for each situation. In patients with a gummy smile, the augmentation procedure crown may be a viable alternative in aesthetic rehabilitation. For Gusmão *et al.* (2006)[15] all surgical techniques and increased clinical crown, aims at the reduction of excessive gingival tissue by removing or repositioning of apical gum line. Pedron *et al.* (2010)[16] stated that periodontal surgeries are appropriate to restore the anatomical characteristics and the relationship between teeth and gum procedures.

For the choice of the appropriate surgical technique for a particular case, you should follow some important criteria such as: evaluating the need for osteotomy, identify the etiology of overexposure gum and locate the distance between the cementum enamel junction and bone crest and between cementum enamel junction to the gingival margin[17]. The case hereby presented in this article, both techniques of internal and external bezel could be used, however, opted for the technique, based on the literature, presented some advantages, such as correction of gingival height, access, when needed, to alveolar bone, feasibility suture ensuring a better healing with coaptation, and provide comfort to the patient during the post-operatório[18].

The DSD, commonly used in cases of prosthetic rehabilitation, proved to be versatile in this work and it allowed using it in virtual periodontal surgical planning. Therefore, this article seems to be one of the first to report a case of periodontal surgery previously planned and developed with the assistance of the DSD. This method, performed on digital images, transfer important information that can be used in the study model, where a diagnostic wax-up accordance with the planning provided[10].

This mechanism is intended as an aid in the treatment plan, providing a better understanding and motivation of the patient who can have a comprehensive view of before and after treatment, and facilitate interdisciplinary communication between dentist and prosthodontics. However, this method has the disadvantage additional cost equipment such as a computer and camera with its accessories, in addition to taking a larger clinical professional time spent to taking snapshots of the patient. But considering the pros and cons, it is believed that the safety and quality of planning as well as the final results

achieved with the use of the DSD method outweigh the additional costs.

4. CONCLUSION

The correct diagnosis of the etiology of "gummy smile" as well as the multidisciplinary knowledge of aesthetic and functional characteristics is of paramount importance to the treatment plan. The approach of helper methods aimed at restoring the "gummy smile" as the technique of DSD, with supporting technical mock-up and surgical guide, provide a differentiated and insurance planning. Thus, the technique of Digital Design Smile proved to be versatile, and can also be used in periodontal surgery planning.

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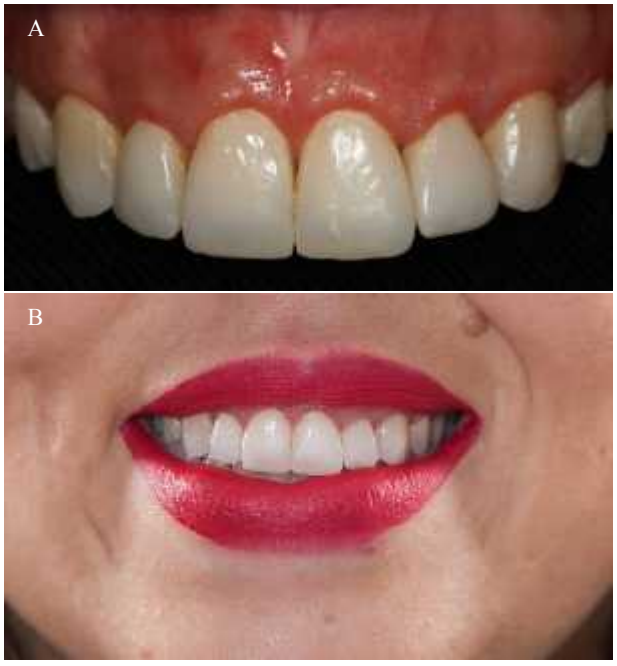

Figure 8. A: anterior and posterior restorations; **B:** final appearance.

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The fine/ festooned biotype gum tends to have an inflammatory response when subjected to physical trauma leading to the development of gingival recession. Already biotype plan/ thicker reacts to trauma with signs of inflammation and gengival[14] growth. The patient had gingival biotype plan / thicker supra-bony pockets.

Now, due to the established diagnosis and characteristics of the smile in question, it becomes easier to choose the type of proper technique for each situation. In patients with a gummy smile, the augmentation procedure crown may be a viable alternative in aesthetic rehabilitation. For Gusmão *et al.* (2006)[15] all surgical techniques and increased clinical crown, aims at the reduction of excessive gingival tissue by removing or repositioning of apical gum line. Pedron *et al.* (2010)[16] stated that periodontal surgeries are appropriate to restore the anatomical characteristics and the relationship between teeth and gum procedures.

For the choice of the appropriate surgical technique for a particular case, you should follow some important criteria such as: evaluating the need for osteotomy, identify the etiology of overexposure gum and locate the distance between the cementum enamel junction and bone crest and between cementum enamel junction to the gingival margin[17]. The case hereby presented in this article, both techniques of internal and external bezel could be used, however, opted for the technique, based on the literature, presented some advantages, such as correction of gingival height, access, when needed, to alveolar bone, feasibility suture ensuring a better healing with coaptation, and provide comfort to the patient during the post-operatório[18].

The DSD, commonly used in cases of prosthetic rehabilitation, proved to be versatile in this work and it allowed using it in virtual periodontal surgical planning. Therefore, this article seems to be one of the first to report a case of periodontal surgery previously planned and developed with the assistance of the DSD. This method, performed on digital images, transfer important information that can be used in the study model, where a diagnostic wax-up accordance with the planning provided[10].

This mechanism is intended as an aid in the treatment plan, providing a better understanding and motivation of the patient who can have a comprehensive view of before and after treatment, and facilitate interdisciplinary communication between dentist and prosthodontics. However, this method has the disadvantage additional cost equipment such as a computer and camera with its accessories, in addition to taking a larger clinical professional time spent to taking snapshots of the patient. But considering the pros and cons, it is believed that the safety and quality of planning as well as the final results

achieved with the use of the DSD method outweigh the additional costs.

4. CONCLUSION

The correct diagnosis of the etiology of "gummy smile" as well as the multidisciplinary knowledge of aesthetic and functional characteristics is of paramount importance to the treatment plan. The approach of helper methods aimed at restoring the "gummy smile" as the technique of DSD, with supporting technical mock-up and surgical guide, provide a differentiated and insurance planning. Thus, the technique of Digital Design Smile proved to be versatile, and can also be used in periodontal surgery planning.

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THE GEL CYTOTOXICITY IN RELATION TO THE DENTAL PULP

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ABSTRACT

The technique of tooth whitening has evolved, with new techniques brought comfort and perspective to patients, therefore this study is to evaluate the response of vital teeth pulp, bleached with the technique in practice in peroxide concentration 35% hydrogen. We selected patients with indications for extractions of mandibular central incisors by orthodontic reasons. In two sessions were applied teeth bleaching gel for 45 minutes, according to manufacturer's guidelines. After 1 week, the teeth were extracted. Afterward, the teeth were placed in a jar with formaldehyde, keeping up the dehydration and clearing. Later, it was embedded in paraffin and then cut and staining of slides. In the vestibular region, where the bleaching agent was applied there was a sharp reaction of odontoblasts disorganized, losing their character and palisade layer juxtaposed. We noted that the core of odontoblasts are pyknotic. In lingual region where no bleaching agent was applied, there is the organization of odontoblasts. Therefore, changes occurred in the tooth-pulp, but the pulp tissue is compatible with normality.

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1. INTRODUCTION

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The whitening occurs because the tooth structure is permeable to bleaching agents able of diffusing into the enamel and dentin oxidation occurring[2], consisting in a chemical process where organic materials are converted into carbon dioxide and water. The pigments are composed of large amounts of carbon molecules. These are broken and converted into intermediate compounds (smaller carbon chains) that are whiter. This chemical reaction changes the type, number and relative position of the atoms that compose these molecules. During the whitening the carbon chains are transformed into CO_2 and H_2O, being gradually released along with the nascent oxygen[3].

Currently there is a great quest for the "white smile", with extensive media coverage and, consequently, an increased interest by patients in relation to treatment, with the advantage of being a conservative technique without wear of dental elements[4]. However, there is controversy about the biocompatibility relative to pulp organ[5-11].

The realization clinical research using the whitening gel is important because the bleaching agents can reach the pulp chamber and cause damage to the cellular membrane, leading to the death of pulp cells by apoptosis or necrosis in lower incisors, probably due to minor thickness enamel and dentin[10,12]. Thus, the goal of this research was to evaluate the pulpal cytotoxicity with the use of hydrogen peroxide whitening gel to 35% in incisors extracted after 1 week of whitening technique.

2. MATERIAL AND METHODS

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At the end of clinic session, the gel was removed with an endodontic sucking and washed with water/ air using a triple syringe for complete removal of the gel. After this procedure was applied colorless neutral fluoride for 10 minutes in order to prevent tooth sensitivity. The interval between bleaching sessions was 7 days. The extractions were performed one week later under local anesthesia.

After tooth extraction performed by extraction alveolar route with forceps, each tooth was kept wrapped in gauze soaked in 0.9% saline solution, and the final suture procedures were performed in "X" external. The patient was monitored by the researcher, in the healing process, during the period of 45 days after the surgical procedure. After the extraction of each dental element, all gingival and periodontal tissue were scraped using a scalpel handle (Golgran, São Paulo, Brazil) fitted with blade number 12 (Lamedid and Commercial Services Ltda., Barueri, São Paulo, Brazil), cleaned with a rubber cup, attached to a handpiece (Duratec 23D, Kavo, Germany).

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For each specimen studied, took advantage of the tissue sections with evidence of dental pulp in its long axis. For each specimen (n = 3), 10 glass slides were prepared and stained with hematoxylin and eosin (H/ E). Each of them possessed 5 tissue sections. All tissue sections were microscopically analyzed, tabulated and subjected to statistical analysis.

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Changes in the pulp tissue were observed and exemplified in Figure 1.

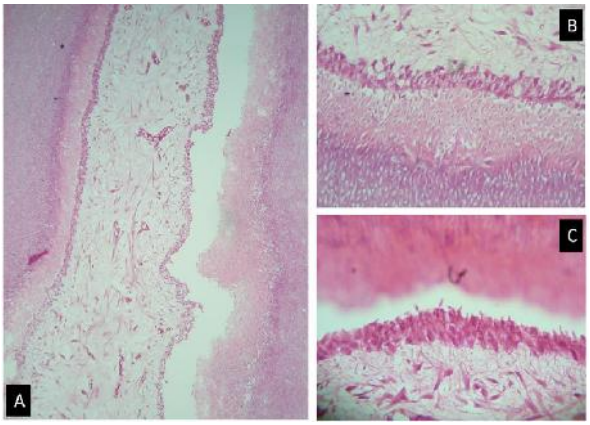

Figure 1. Microscopic appearance of the pulp-dentin of a tooth subjected to treatment with whitening gel complex. **A:** Overview (40x magnification); **B:** (400x magnification), Region Lingual: organization of odontoblasts; **C:** (400x magnification), Vestibular Region: disruption of odontoblasts in relation to the application of the bleaching agent region, being possible to observe pyknotic nuclei.

The analysis showed Lingual Region odontoblasts found themselves neatly juxtaposed with feature layer and palisade (Figure 1B). Already in the vestibular region, there were irregularities in the layer of odontoblasts, dentin in the pre-and dentin layer. It was observed that the odontoblasts lost their characteristic juxtaposed layer and palisade. This made it become a disorganized reaction and this is shown where the production of pre-dentin and dentin is decreased (Figure 1C).

4. DISCUSSION

The bleaching agents act mainly by oxidation of organic compounds. These agents are highly unstable and, when in contact with the tissue, release free (especially nascent oxygen) radicals that oxidize the pigments[1,3,5].

Although tooth enamel is a mineral structure, studies have reported that both the hydrogen peroxide and carbamide peroxide penetrates the enamel and dentin. Subsequently, they enter the pulp chamber at various rates and widespread amount is dependent on its concentration, the length of time that the agent is in contact with the dentin, the presence of cracks or wear and presence of restorations[7,11,15,16].

Other laboratory studies, *in vitro* and *in situ* were performed to evaluate the effects of practice on the technique of tooth structure, showing that the technique does not affect tissues and dental structures[17]. Yet other studies have shown the diffusion of hydrogen peroxide (H_2O_2) for enamel and dentin[5] due to its ability to denature proteins and low molecular weight, penetration is facilitated[10] this are thus demonstrated cytopathic effects in the cells even after single application of this product in enamel[6], or multiple sessions of the application[11].

In this *in vivo* study was evaluated the presence of histological changes in the pulp-dentin complex due to the use of H_2O_2 to 35% on the buccal surfaces of the lower incisors selected as the study of Gökay *et al.* (2005)[18], but in a research *in vitro*. Those authors reported in the literature several studies that assessed the laboratory level different topics related to bleaching and pulp organ[6-11], yet few in vivo studies as performed in this study. It is especially difficult to find intact teeth incisors with orthodontic indication for extraction.

The use of bleaching agents causes the rupture of the protein matrix that occurs by increasing the porosity of the enamel can induce side effects such permeability and dental tissues may lead to post-operative sensitivity, and also allowing for the promotion of morphologic changes tissue and in dental structures[6,10].

In the lingual region of the teeth receiving the whitening gel showed normal histological characteristics of the pulp tissue. There were irregularities in the odontoblasts, dentin and pre-dentine layer in the region where the whitening gel is applied. In this case, there was no light activation pulpal temperature changes occur, when they are associated with the light source; in other words, enhanced by the bleaching gel apparatus raises the temperature of the bleaching gel and result in increased temperature intrapulpal, causing damage to the pulp[7]. It is noteworthy that the light source is not responsible for activity whitening bleaching material, it acts as an accelerator of the reaction, making the procedure quicker. However, it is known that even in situations where no light is applied, the oxidation reaction is usually responsible for the whitening[12].

The Professor Costa's *et al.* (2010)[6] group evaluated the whitening in a dental office of 6 premolars and 4 incisors, under hydrogen peroxide at 35%, and subsequently analyze the pulp response, using the same methodology of this study and proved irreversible changes only in lower incisors, corroborated this result. The premolars met irregularities in the odontoblast layer, predentin and dentin but without necrosis. The root pulp such teeth showed dilation of blood vessels, and no change was observed in premolars. It was shown in that research with the thickness of enamel and dentin is crucial in the occurrence of irreversible pulp damage. This is the grounds for the selection of the lower incisors by placing the test the biocompatibility of the bleaching agent and its effect on pulp level.

The diffusion of bleaching material through enamel and dentin has been observed in laboratory studies. In these studies, regardless of the light source used, the hydrogen peroxide was able to cross the entire thickness of enamel and dentin, reaching the layer of cultured cells and causing reduction in metabolism and significant morphological changes, this finding is corroborated by other studies[7,9,10,11].

The contact time of the bleaching agent to the tooth surface influences the distribution of the components of bleaching agent to reach the pulp, the greater the space time of contact of the whitening gel with the largest dental element is its penetration, independent of the concentration of the bleaching gel[9], although this study did not evaluate different concentrations. Finally, it should be considered that could provide selected patients anatomical differences between the teeth, variable in thickness enamel and dentin, as this plays an important role in protecting the pulp tissue against the toxic products released by bleaching agents, which diffuse into the tooth surface.

5. CONCLUSION

Based on the scope of this study we suggest that tooth bleaching with hydrogen peroxide at 35% may produce irregularities in the odontoblast layer, preden-

tin and dentin in incisors, but without necrosis.

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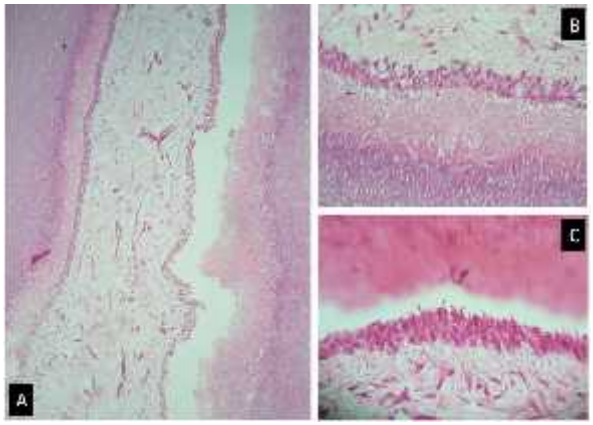

Figure 1. Microscopic appearance of the pulp-dentin of a tooth subjected to treatment with whitening gel complex. **A:** Overview (40x magnification); **B:** (400x magnification), Region Lingual: organization of odontoblasts; **C:** (400x magnification), Vestibular Region: disruption of odontoblasts in relation to the application of the bleaching agent region, being possible to observe pyknotic nuclei.

The analysis showed Lingual Region odontoblasts found themselves neatly juxtaposed with feature layer and palisade (Figure 1B). Already in the vestibular region, there were irregularities in the layer of odontoblasts, dentin in the pre-and dentin layer. It was observed that the odontoblasts lost their characteristic juxtaposed layer and palisade. This made it become a disorganized reaction and this is shown where the production of pre-dentin and dentin is decreased (Figure 1C).

4. DISCUSSION

The bleaching agents act mainly by oxidation of organic compounds. These agents are highly unstable and, when in contact with the tissue, release free (especially nascent oxygen) radicals that oxidize the pigments[1,3,5].

Although tooth enamel is a mineral structure, studies have reported that both the hydrogen peroxide and carbamide peroxide penetrates the enamel and dentin. Subsequently, they enter the pulp chamber at various rates and widespread amount is dependent on its concentration, the length of time that the agent is in contact with the dentin, the presence of cracks or wear and presence of restorations[7,11,15,16].

Other laboratory studies, *in vitro* and *in situ* were performed to evaluate the effects of practice on the technique of tooth structure, showing that the technique does not affect tissues and dental structures[17]. Yet other studies have shown the diffusion of hydrogen peroxide (H_2O_2) for enamel and dentin[5] due to its ability to denature proteins and low molecular weight, penetration is facilitated[10] this are thus demonstrated cytopathic effects in the cells even after single application of this product in enamel[6], or multiple sessions of the application[11].

In this *in vivo* study was evaluated the presence of histological changes in the pulp-dentin complex due to the use of H_2O_2 to 35% on the buccal surfaces of the lower incisors selected as the study of Gökay *et al.* (2005)[18], but in a research *in vitro*. Those authors reported in the literature several studies that assessed the laboratory level different topics related to bleaching and pulp organ[6-11], yet few in vivo studies as performed in this study. It is especially difficult to find intact teeth incisors with orthodontic indication for extraction.

The use of bleaching agents causes the rupture of the protein matrix that occurs by increasing the porosity of the enamel can induce side effects such permeability and dental tissues may lead to post-operative sensitivity, and also allowing for the promotion of morphologic changes tissue and in dental structures[6,10].

In the lingual region of the teeth receiving the whitening gel showed normal histological characteristics of the pulp tissue. There were irregularities in the odontoblasts, dentin and pre-dentine layer in the region where the whitening gel is applied. In this case, there was no light activation pulpal temperature changes occur, when they are associated with the light source; in other words, enhanced by the bleaching gel apparatus raises the temperature of the bleaching gel and result in increased temperature intrapulpal, causing damage to the pulp[7]. It is noteworthy that the light source is not responsible for activity whitening bleaching material, it acts as an accelerator of the reaction, making the procedure quicker. However, it is known that even in situations where no light is applied, the oxidation reaction is usually responsible for the whitening[12].

The Professor Costa's *et al.* (2010)[6] group evaluated the whitening in a dental office of 6 premolars and 4 incisors, under hydrogen peroxide at 35%, and subsequently analyze the pulp response, using the same methodology of this study and proved irreversible changes only in lower incisors, corroborated this result. The premolars met irregularities in the odontoblast layer, predentin and dentin but without necrosis. The root pulp such teeth showed dilation of blood vessels, and no change was observed in premolars. It was shown in that research with the thickness of enamel and dentin is crucial in the occurrence of irreversible pulp damage. This is the grounds for the selection of the lower incisors by placing the test the biocompatibility of the bleaching agent and its effect on pulp level.

The diffusion of bleaching material through enamel and dentin has been observed in laboratory studies. In these studies, regardless of the light source used, the hydrogen peroxide was able to cross the entire thickness of enamel and dentin, reaching the layer of cultured cells and causing reduction in metabolism and significant morphological changes, this finding is corroborated by other studies[7,9,10,11].

The contact time of the bleaching agent to the tooth surface influences the distribution of the components of bleaching agent to reach the pulp, the greater the space time of contact of the whitening gel with the largest dental element is its penetration, independent of the concentration of the bleaching gel[9], although this study did not evaluate different concentrations. Finally, it should be considered that could provide selected patients anatomical differences between the teeth, variable in thickness enamel and dentin, as this plays an important role in protecting the pulp tissue against the toxic products released by bleaching agents, which diffuse into the tooth surface.

5. CONCLUSION

Based on the scope of this study we suggest that tooth bleaching with hydrogen peroxide at 35% may produce irregularities in the odontoblast layer, preden-

tin and dentin in incisors, but without necrosis.

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SEMI-ADJUSTABLE ARTICULATORS

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ABSTRACT

The semi-adjustable articulator (SAA) plays an important role in Dentistry, since it allows adequate diagnosis and treatment planning to promote the oral health of our patients. The SAA reduces the intervention of prosthodontists; when well employed, it simplifies the daily clinical routine, reducing the number of sessions, chair time and need of interventions in the patient's mouth, besides allowing more accurate procedures, consequently without damages to the stomatognathic system.

KEYWORDS: semi-adjustable articulator, verticulator, articulator mounting, articulator parts.

1. INTRODUCTION

In dental practice, it is noticed that dental professionals usually conduct diagnosis only by oral examination, with aid of dental mirror and dental probe, often not performing radiographic examination.

Diagnosis in Dentistry is the basis for correct intervention and treatment success. With regard to prosthodontics, some auxiliary diagnostic methods are extremely importance to enhance the establishment of precise treatment planning, including the utilization of articulators.

There has been concern with the reproduction of maxillomandibular relationship for more than one hundred years, in an attempt to allow dentists to have a copy image of the patient's mouth in their hands. The articulators were designed for that purpose.

The articulator was designed to allow fixation of dental casts for recording of intermaxillary relationships and reproduction of mandibular movements of interest in prosthodontics.

With the evolution of materials, researches and technology, the semi-adjustable articulator (SAA) became increasingly correct as to the accuracy of reproduction. This appliance is highly advantageous for dental professionals in modern dentistry.

The SAA also presents some limitations inherent to their mechanical nature, due to the lack of muscles, ligaments, nerves, emotional and biological factors, aspects related to living beings and proprioceptive memory; these limitations should be taken into account to avoid mistakes.

When employed by an operator with good technical dexterity, under accurate clinical criteria, skillful hands and good biomechanical knowledge, the articulator is very useful and presents a good work-cost relationship. It may allow time saving, since an apparently complex case may be easy to solve and have a good prognosis after proper mounting and analysis with the SAA.

It has been statistically demonstrated that the SAA is a practical instrument, with proven veracity and fidelity. Its utilization reduces the number of intraoral interventions, since most occlusal adjustments might be performed directly on the articulator.

Its utilization has become fundamental for dental professionals in current practice, since it allows easy achievement of more accurate works without further damage to the stomatognathic system.

2. MATERIAL AND METHODS

The following literature databases were searched: General Science Index, Medline, Pubmed, EBSCO host and CAPES Periodicals. Studies were selected if they scope were directly related to semi-adjustable articulators. Studies published from 1910 to 2012 were included according to the author's analysis. The keywords of this study were utilized to the consult the databases.

3. LITERATURA REVIEW

Villa (1952)[1], recounts in his book, the emergence of the first models of articulators, according to it, Ga-

riot, in 1805, was the first author to articulate maxillary and mandibular dental casts to maintain the vertical dimension of occlusion. This author also introduced the guiding planes to record the vertical dimension of occlusion. Evan, in 1840, presented a type of articulator that was able to reproduce lateral mandibular movements, with a mobile lower member and fixed upper member. Bonwill, in 1858, described the mandibular condyle movement in horizontal, postero-anterior direction during mouth opening. This author presented a type of articulator that reproduced the lateral mandibular movements together with the horizontal condylar movement. Walker, in 1896, demonstrated the theory of condylar movement during mouth opening, timely correcting the mistake of Bonwill (1858). According to Walker, the condyle presented forward and downward displacement during mouth opening, following the inclination of the glenoid cavity. His anatomical articulator was able to reproduce these movements. Snow, in 1900, introduced the facebow for utilization with the articulator, with a view to transfer the guiding planes from the patient's mouth to the articulator, following the condyle-incisor distance.

Gysi (1910)[2], invented a unique articulator, which had a device adapted incisal guide. This instrument was very advanced for the time, and presented as a novelty the possibility of extra-oral records, however this articulator was not well accepted by professionals of the time, so the surging Gysi Simplex.

Marchetti *et al.* (1980)[3] assigned the term "mechanical examination" to the analysis of dental casts mounted on SAA, defining it as the mounting of maxillary and mandibular dental casts in an appliance that reproduces the mandibular movements. This procedure is fundamental for treatment planning, since it allows the analysis of opposing teeth and the efforts applied to them.

Tamaki (1981)[4] stated that the SAA reproduces the mandibular movements with nearly complete accuracy and thus are the most indicated in Dentistry, due to the need of short chair time to adjust it.

Motsch (1985)[5] states that premature contacts may not be detected by direct occlusal analysis on the patient's mouth, especially if these contacts involve teeth with mobility, which may be displaced or intruded; conversely, on the SAA, these contacts are more evident due to the rigidity of dental casts.

According to Posselt (1981)[6], Santos (1996)[7], Mezzomo (1994)[8] and koyano (2012)[9], successful diagnosis and treatment depend on the good sense and dexterity of dental professionals. The SAA is employed as an auxiliary tool and may only be successfully used if the dental professional is familiarized with the principles of occlusion and mandibular recording.

Ash & Ramfjord (1987)[10] mentioned that the articulator is a mechanical instrument used to connect maxillary and mandibular dental casts of patients, so as diagnostic and restorative procedures may be conducted without the presence of the patient.

According to Stiz (1994)[11], the non-utilization of dental casts mounted on SAA as an auxiliary tool for diagnosis may impair the analysis and conclusions on the oral health status of the patient. This occurs because the teeth are dynamic organs closely related with the soft tissues, bones, joints and ligaments; they also reflect the general health status of the patient.

Fonseca (1994)[12] highlights that "*patients with severe craniomandibular dysfunction are often submitted to general dental treatments without diagnosis of their condition by the dental professional*".

According to Koyano (2012)[9], the SAA is a mechanical appliance that allows adaptation of maxillary and mandibular dental casts of patients, with simulation of the temporomandibular junction and reproduction of some mandibular movements that are fundamental for satisfactory occlusion.

Starcker (2010)[13], reported some advantages of the SAA, including the possibility to reproduce mandibular movements without interference from the neuromuscular system; general visualization of teeth and adjacent structures, especially at the region of second molars, which are often difficult to observe in the presence of soft tissues. However, this author highlights that mounting of dental casts should be careful to allow accurate reproduction of the patient's status.

Souza *et al.* (2001)[14] mentioned the low quality of Wip-Mix (SAA) articulators, whose pieces and components are fabricated with plastic, which often leads to fracture of components due to the low quality of the material and insufficient quality control during fabrication.

Lopes *et al.* (2003)[15] stated that accurate transfer of maxillomandibular relationship from the patient to the articulator depends on several variables, especially the type of articulator employed, technique adopted to transfer the spatial positioning of the maxillary dental cast to the articulator, ability and experience of the operator, accuracy of materials and recording technique, besides the type of material and technique employed for fixation of dental casts to the upper and lower members of the articulator.

Amorin *et al.* (2004)[16] described that patients receiving complete dentures fabricated with aid of articulators report greater comfort and increased masticatory efficiency, better adaptation to the new dentures, and reduced occurrence of soft tissue lesions.

Mounting of dental casts on SAA allows the achievement of several data, such as clear observation

of edentulous spaces and their extent, occluso-gingival height, dental arch curvature, postero-anterior view of dental casts, absence or presence of muscles and ligaments, which may not be noticed during clinical examination of the patient.

The utilization of SAA provides easy observation and treatment planning, allowing the dental professional to perform an assay outside the mouth, foreseeing the probable diagnosis and significantly reducing the risk of iatrogeny.

It should be remembered that the SAA is a valuable instrument for dental professionals, yet it is not a miraculous and failure-proof tool; thus, the possibilities of utilization depend on the professionals handling and caring for this instrument.

Classification of articulators

According to Weinberg (1963 apud TAMAKI 1981[4]), the articulators may be classified into four categories: arbitrary, positional, semi-adjustable and fully adjustable.

- The arbitrary articulator is based on the theories of Monson or Hall. The mobile member is connected to the body by a central point, which allows pendular movements of the member;
- The positional articulator is based on the theory of immutability of vertical dimension. It is characterized by the independence between the upper and lower members.
- The semi-adjustable articulator allows the following adjustments: inclination of condylar path, Bennett angle and incisal path. These articulators include the Gysi, Trubyte and Hanau model H.
- The fully adjustable articulator allows the following settings: inclination of condylar path, Bennett angle, Fischer angle, incisal path, height of pints and intercondylar distance (examples: articulators of Stuart and Di Pietro).

The articulators may be classified as non-adjustable (NAA), fully adjustable (FAA) and semi-adjustable (SAA). The non-adjustable articulators include the simple hinge articulator, the verticulator and the correlator, whose movements and characteristics do not allow reproduction of mandibular movements. One limitation of the simple hinge articulator is the impossibility of lateral movement, associated with an incorrect path of opening and closure compared to the mandible, leading to altered positioning of cusps and consequently to the occurrence of premature contacts when the restoration is placed in the mouth.

These non-adjustable instruments may be employed for single-tooth restorations, in which occasional occlusal changes in the prosthesis may be corrected directly in the patient's mouth, without damage to the chair time and quality of the prosthesis. Thus, the SAA and FAA are better recommended for mounting of dental casts or fabrication of extensive prostheses.

The verticulator and correlator only allow movements in vertical direction; the verticulator is used for mounting of partial dental casts, whereas the correlator may be used with full dental casts.

The advent of FAA was based on the concepts of Gnathology, which considers the reproduction of all mandibular movements as fundamental in prosthodontics. These articulators are able to reproduce all determinants of occlusal morphology and thus allow the achievement of prostheses that are more compatible with the actual status of the patient. This is very important to reduce the chair time required for occlusal adjustment of prostheses.

The problem with the acceptance of FAA is related to the complex mounting and high cost of these articulators. Therefore, due to the appearance and optimization of SAA, its utilization has been reduced, even though it is recommended by many clinicians and researchers.

The SAA, whose initial prototype was the Whip-Mix articulator, is able to partially reproduce the determinants of occlusal morphology. Therefore, they present limitations when compared to the FAA; however, these limitations may be compensated for and thus the prostheses fabricated with aid of SAA are compatible with those achieved with aid of FAA. This fact, combined to the simple mounting, has currently made the SAA the instrument of choice for most cases. As mentioned by Shavel, "*a dentist can do a full-mouth rehab case on a semi-adjustable articulator as long as he has a fully adjustable brain*".

Such SAA may also be divided into ArCon (condyles on the lower member, e.g. Whip-Mix, Denar, Bio-Art, Gnatus, etc.) or non-ArCon (condyles on the upper member, e.g. Dentatus, Hanau).

Articulator parts

Body – central portion to which the members are fixated. Its function is to establish the bicondylar distance and the distance between the members.

Members – horizontal extensions on which the mounting guides and plates are fixated.

Condylar balls – represent the condyles, with small, medium or large intercondylar distance.

Angulation of the glenoid cavity roof – guides the protrusion movements of the articulator.

Condylar housing – guides the protrusion movements of the articulator.

Incisor table – located at the anterior portion of the lower member; provides support to the incisal pin.

Incisal pin – is supported on the incisal table and

maintains the height between the members.

Mounting plates – receive application of plaster for fixation of dental casts to the articulator.

Facebow – accessory device employed for mounting of the maxillary dental cast in the articulator and establishment of intercondylar distance (S, M, L).

Nose piece – stabilizes the assembly on the basis of the Nasion point (glabella).

Bitefork – Allows registration of indentation.

Working positions: centric relation (CR) and maximum intercuspation (MI)

Before description of the occlusal recording techniques, the position to be adopted for mounting of dental casts on the SAA should be discussed. That is to say, the first step before occlusal recording is the definition of the maxillomandibular position.

Different clinical situations influence the selection of mandibular positioning. Thus, it may be stated that the main factor for selection of positioning would be the occlusal stability.

When fixed dentures or single-tooth restorations are fabricated and there is occlusal stability, the maximum intercuspation position (MI) of the patient may be considered for recording and for the prosthesis. Recording in MI follows the mechanism of neurological perception of the periodontal ligament of teeth normally occluding at the opposite side. This allows maintenance of the patient's vertical dimension of occlusion and also compensates for some limitations of the SAA.

In fact, in such cases, the best situation would be if recording was unnecessary, i.e. if the occlusal stability of dental casts is enough to eliminate the need of further recording. The dental casts are then directly mounted against each other, after removal of occasional bubbles form the surface of dental casts. This is common in the fabrication of single-tooth restorations and unilateral fixed dentures with stable dental casts. In these cases, the maxillary dental cast is conventionally mounted with aid of the facebow, and the mandibular dental cast is manually positioned in intercuspation against the maxillary dental arch.

After fabrication of the prosthesis and during adjustment in the patient's mouth, the professional should avoid the introduction of "new" premature contacts in centric relation or during mandibular movement. Such contacts should be eliminated only by adjustments on the prosthesis.

On the other hand, in cases of extensive oral rehabilitation, with periodontal problems or loss of occlusion dimension, the occlusal stability may be absent or the occlusion may interfere with the health of the stomatognathic system. In these cases, since the pathologies are directly related with the occlusion, the MI should not be adopted for the prosthesis.

Therefore, these cases require utilization of condylar positioning for establishment of the working position. This condylar position is the centric relation (CR); after being adopted as working position, it should be harmonious with the dental relationship. Thus, if CR is to be adopted as a therapeutic position, occlusal adjustment of remaining teeth is required for achievement of a stable occlusion. This new maxillomandibular position, in which the tooth contacts are harmonious with the condylar position in centric relation (CR), is called "centric relation occlusion (CRO)".

After establishment of the maxillomandibular relationship, two factors should be considered for interoccusal recording: the recording material and the care to be taken to compensate for the limitations of SAA.

Limitations of SAA and their compensations

As previously mentioned, some limitations of the SAA impair the reproduction of all characteristics observed in the temporomandibular joint, which consequently should be acknowledged and compensated for to improve the final occlusal outcome of the prosthesis.

The influence of these limitations is often related with three occlusal aspects: direction of ridges and grooves, cusp height and fossa depth, and conformation of the palatal cavity of anterior teeth.

Several limitations and compensations of SAA are described in the literature, the most important of which will be described in this section.

Shape and angulation of the articular eminence

Limitation: the upper wall of the "mandibular cavity" of the SAA is straight and rigid, whereas this structure in the TMJ is curved. That is to say, only the initial and final positions of mandibular movement are recorded. Therefore, the actual paths of the condyles are not accurately recorded on the SAA. Consequently, carving of the occlusal surface of posterior teeth increases the risk of occurrence of undesirable contacts during mandibular movements.

Compensation: customization of the anterior guidance while the provisional crowns are worn and its transfer to the incisal table on the articulator reduces the possibility of contacts between the posterior teeth during excursive mandibular movements. This customization guides the establishment of cusp height and fossa depth. These clinical procedures are described in the section on provisional crowns.

Recording of intercondylar distance

Limitation: the SAA records only three intercon-

dylar distances (small, medium and large), whereas the patients may present different variations in these distances. According to the determinants of occlusal morphology, this factor is known to influence the direction of ridges and grooves of posterior teeth and the conformation of the palatal cavity of anterior teeth. Thus, occlusal interferences may be incorporated in prostheses if this factor is not compensated for.

Compensation: customization of anterior guidance.

Immediate lateral displacement

Limitation: in many situations, the condyle at the non-working side exhibits mild movement in lateral direction before contacting the medial wall of the mandibular fossa and initiating its downward, forward and inward movement. This characteristic is observed in nearly half of the population and has been called immediate lateral displacement.

In the SAA, the condylar ball is in close contact with the medial wall of the metallic mandibular fossa and thus is unable to reproduce these characteristics.

When present, the immediate lateral displacement may influence the cusp height and fossa depth.

Compensation: customization of anterior guidance. Prostheses with metallic occlusal surfaces may be submitted to surface treatment with aluminum oxide sandblasting before provisional cementation; this procedure allows the identification of occasional interferences, which will be noticed as shiny spots and should be eliminated before definitive cementation.

Position of mandibular rotation axis

Limitation: the rotation axis transferred to the SAA by the facebow does not correspond to the actual rotation axis present on the condyles. Thus, there may be differences in the opening and closure paths between the articulator and the mandible, which will influence the correct positioning of cusps and posterior teeth in the prostheses.

Compensation: interocclusal recording in vertical dimension of occlusion for mounting of dental casts, or occlusal recording with minimum thickness for dental casts mounted in centric relation.

Materials employed

The materials most commonly employed for intermaxillary recording include waxes, addition and condensation silicones and acrylic resin.

For mounting of dental casts in centric relation, wax or addition silicone may be employed for intermaxillary recording, since these cases require a mild separation between the teeth to record only the condylar position. On the other hand, resin copings are preferable for intermaxillary recording for dental casts mounted in vertical dimension of occlusion.

Recording techniques for study and working casts

The utilization of articulators aims to simulate the mandibular movements and reduce the time spent for intraoral adjustment of prostheses. However, the clinical relevance of articulators is directly associated with the accuracy of interocclusal relation of dental casts mounted on the articulator. When mounting of dental casts on the articulator does not correspond to the occlusal relation of the patient, there will be little benefit from its use. Thus, the ability of professionals to mount the dental casts has more influence on the final quality of the restoration than complete setting of semi-adjustable articulators. Besides saving chair time, more accurate records reduce the possibility of restorations without occlusal contact or requiring excessive adjustment. However, some discrepancy in interocclusal recording is expected, related both to the materials employed and to the several clinical difficulties. Despite of that, these errors should be reduced by careful selection and achievement of recordings among the several methods and materials available for that purpose.

Mounting of study casts on SAA

Since the main semi-adjustable articulators commercially available are similar to the Whip-mix, description of the technique for mounting of dental casts will follow the rules established for this type of articulator; they may also be adapted for application with other articulators.

Mounting of maxillary cast with facebow

The facebow allows mounting of the maxillary dental cast on the SAA at the same spatial positioning of the maxilla in relation to the skull. It also allows transfer of the patient's intercondylar distance and rotation axis of the condyles to the articulator.

Assunção *et al.* (2000)[17] reported that the operator influences the final outcome of mounting of maxillary dental casts on the articulator. The possible occlusal changes induced by the professional when mounting the maxillary dental cast on the articulator are not very relevant in the fabrication of complete removable dentures, since they act as a unit supported by resilient mucosa. The errors produced during mounting and transfer of the maxillary dental cast to the articulator with aid of an arbitrary facebow are related to the inherent limitations of the appliances and techniques, as well as to the inability of the operator to use these instruments.

The facebow is positioned by placing the bite-fork in the patient's mouth with three portions of low fusing impression compound, being one at the anterior region and two at the posterior region. The bite-fork is

placed in the patient's mouth with its handle following the patient's facial midline, molding only the cusp tips and incisal edges of maxillary teeth. After cooling of the impression compound, the bite-fork is removed, the molding is checked and the excess impression compound is removed, maintaining only the areas with molding of cusp tips, to allow complete seating of the dental cast. If this does not occur, these moldings may be enhanced with zinc oxide-eugenol paste or similar materials.

The bite-fork is placed in the mouth and should be stabilized during placement of the facebow. For that purpose, three portions of low fusing impression compound are also placed on the lower portion of the bite-fork, so that the mandibular teeth may keep it stable. Cotton rolls or the patient's hands may also be helpful for this purpose. The facebow is then positioned and connected to the bite-fork handle, keeping them closer. Following, the ear pieces are introduced in the patient's external ears; the patient is asked to keep the position of the facebow by applying a gentle forward and upward pressure with the hands, to keep it as close as possible to the condyles. The third point of the facebow, namely the nose piece, is then fixated to the transverse bar of the facebow. At this step, the intercondylar distance is classified as small, medium or large, as indicated on the frontal portion of the facebow by the letters S, M, L, or by the numbers 1, 2, 3, depending on the brand of articulator.

The facebow is removed by loosening the central screw at the center of the transverse bar and asking the patient to slowly open the mouth.

For mounting of the maxillary dental cast on the articulator, the condylar balls simulating the condyles of the TMJ present three positions for mounting, according to the intercondylar distance established by the facebow. Adjustment is performed by utilization of spacers on the condylar guidance: no spacer for the small, one spacer for the medium, and two spacers for the large intercondylar distance. The chamfered aspect of the spacer should be turned toward the condylar guidance.

After screwing the mounting plate to the upper member of the articulator, the facebow is positioned against the articulator body with one hand and held by the other hand; the rods on the external aspects of condylar guidance are placed in holes in the ear pieces and the pin is tightened. For mounting of the maxillary dental cast, the pin should be removed from the upper member of the articulator and the dental cast is positioned following the molding of cusp tips on the bite-fork, to avoid its vertical movement.

The dental cast is fixated to the mounting plate with a small amount of special plaster complemented with stone; the facebow is then removed and the incisal pin is placed with the rounded end contacting the incisal table, keeping the upper member against the lower member.

Zanetti & Ribas (2001)[18] developed a transfer tray in an attempt to simplify and improve the accuracy of mounting of the maxillary dental cast on the articulator. This allows transfer of maxillary arch recordings to the articulator in a single step, without the need of recording bases and guiding planes, by utilization of the bite-fork associated with the tray, in which molding is achieved and transferred by the tray on the facebow.

Mounting of mandibular dental cast and recording of CR

Since the centric relation (CR) is a craniomandibular position not related with the teeth, recording of this position should be achieved with the teeth separated as minimally as possible, to compensate for the first limitation of the SAA.

This is facilitated by direct placement of a chemically cured acrylic resin jig in the mouth, involving the maxillary central incisors and extending up to 2 cm in palatal direction; this jig aims to release the memory of mechanoreceptors in the periodontal ligament and thus enhance the mandibular manipulation in centric relation. The teeth should be lubricated with petroleum jelly or isolated with aluminum foil to avoid the adhesion of resin on them; the resin should be placed during the plastic phase and the mandible should be guided into centric relation position during polymerization.

After finishing, the jig should be stable and present only one contact point with only one opposing tooth, allowing minimum separation of posterior teeth.

Accorsi (2001)[19] described the utilization of acetate sheets (leaf gauge) to help in mandibular positioning in CR. Since then, due to its simplicity, this technique has been diffused and is currently widely employed for achievement of interocclusal recording and accomplishment of occlusal adjustment. It has been used not only for oral rehabilitation, such as by orthodontists and prosthodontists, but also in undergraduate and graduate courses in Dentistry. This author reported that the variations among operators observed in this technique suggest that its validity is doubtful and that the operator should be intensively trained, especially for mandibular manipulation, thus demonstrating its limitation for the achievement of a true, stable mandibular centric relation. The method described by Long comprises placement of acetate sheets (leaf "gauge") in sufficient number to separate the posterior teeth.

Santos (1996)[7] described that Dawson's bilateral manipulation method would be the most recommend-

ed. In this technique, the thumbs are placed on the patient's chin and the other fingers are placed under the mandibular base. The patient is placed in supine position with the professional behind the head; the professional then stabilizes the patient's head against the abdomen and guides opening and closure movements.

The teeth should gently press the mandible upwards, so that the condyles are more superiorly positioned against the articular eminence, with the articular disc interposed between these structures; the movement should be slow, gentle and no greater than 2 cm, allowing the condyles to perform only the rotation movement. During manipulation, the patient should not feel any symptoms in the temporomandibular joint; if this occurs, the pathology should be treated before the procedures for centric relation recording are conducted.

Jankelson & Radke (1978)[20] mentioned that simple mandibular manipulation into centric relation without any concern with the tension and stress applied on the neuromuscular elements of the stomatognathic system is an improper procedure, since muscle relaxation is a pre-requirement for achievement of a comfortable occlusal position for the patient, consequently keeping the relaxation and harmony of muscles.

When the mandible is manipulated into centric relation without utilization of the jig, the first tooth contact corresponds to the centric relation position. If the operator presses the mandible beyond these contacts, it will slide in anterior and/or lateral direction up to maximum intercuspation. The first centric contact should be identified with acetate and articulating paper, to check the accuracy of mounting of dental casts in CR.

Recording is obtained with softened wax, addition silicone or chemically cured acrylic resin in the mouth; it is then placed on the maxillary dental cast and the mandibular dental cast is positioned against the recording with the articulator turned upside down; both should be joined with elastics or wood sticks fixated on the dental casts with low fusing impression compound or sticky wax.

At this stage, the incisal pin should be increased in 1 to 2 mm to compensate for the thickness of recording; the incisal pin is then unscrewed after stone setting, allowing the teeth to occlude in centric relation position, with the upper member of the articulator parallel to the lower member.

During mounting of dental casts in centric relation, the condylar balls should be correctly and passively placed in the condylar guidance, i.e. at the intersection between the lateral and posterior walls; to avoid this, the condylar balls may be locked by tightening the screw of the lateral rod of the condylar guidance, moved in opposite direction.

After stone setting, the guidance should be set to average values, i.e. 30º for antero-posterior inclination and 15º for the Bennett angle. So far, no scientific studies have demonstrated that customization of these guidance might be more beneficial to the final outcome of prostheses than setting to average values.

After mounting of dental casts on the SAA, the most important step is to check the agreement of occlusal contacts in centric relation position between the dental casts and the mouth. For that purpose, the teeth presenting contacts in this position are initially checked with aid of acetate sheets and identified with articulating paper. These procedures are then repeated in the mouth; if there is no agreement, recording and mounting on the articulator should be repeated.

Mounting of dental casts in centric relation position on the SAA is then completed, with a view to enhance the visualization of maxillomandibular relationship and analyze the presence of premature contacts and mandibular deviation in lateral and/or anterior direction.

4. CONCLUSION

Several authors highlight the importance of utilization of articulators in dental practice.

Dental professionals should always make use of articulators in cases of extensive oral rehabilitation, since this may interfere with the mastication of patients and cause even greater damage, instead of solving any existing problem.

The increased experience with utilization of this appliance increases the technical skills, facilitating the diagnosis of occasional problems that might remain undiagnosed by the dental professional if only clinical oral examination was performed.

Due to the several types of articulators commercially available, dental professionals should select their appliances on the basis of suitability to their needs and easy handling; also, the manufacturer's instructions should be followed for achievement of all benefits provided by these appliances.

Considering these facilities, and the rich information provided by SAA, in many cases its utilization is fundamental for treatment planning, allowing assessment, establishment of the probable prognosis and significant reduction in the risk of iatrogeny. However, according to Posselt (1981)[6], Santos (1996)[7], Mezzomo (1994)[8] and Tannmala (2012)[21], successful diagnosis and treatment depend on the clinical criteria and dexterity of dental professionals. The SAA is an auxiliary tool and may only be successfully applied if the professional is familiarized with the principles of occlusion and mandibular recording.

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SEMI-ADJUSTABLE ARTICULATORS

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ABSTRACT

The semi-adjustable articulator (SAA) plays an important role in Dentistry, since it allows adequate diagnosis and treatment planning to promote the oral health of our patients. The SAA reduces the intervention of prosthodontists; when well employed, it simplifies the daily clinical routine, reducing the number of sessions, chair time and need of interventions in the patient's mouth, besides allowing more accurate procedures, consequently without damages to the stomatognathic system.

KEYWORDS: semi-adjustable articulator, verticulator, articulator mounting, articulator parts.

1. INTRODUCTION

In dental practice, it is noticed that dental professionals usually conduct diagnosis only by oral examination, with aid of dental mirror and dental probe, often not performing radiographic examination.

Diagnosis in Dentistry is the basis for correct intervention and treatment success. With regard to prosthodontics, some auxiliary diagnostic methods are extremely importance to enhance the establishment of precise treatment planning, including the utilization of articulators.

There has been concern with the reproduction of maxillomandibular relationship for more than one hundred years, in an attempt to allow dentists to have a copy image of the patient's mouth in their hands. The articulators were designed for that purpose.

The articulator was designed to allow fixation of dental casts for recording of intermaxillary relationships and reproduction of mandibular movements of interest in prosthodontics.

With the evolution of materials, researches and technology, the semi-adjustable articulator (SAA) became increasingly correct as to the accuracy of reproduction. This appliance is highly advantageous for dental professionals in modern dentistry.

The SAA also presents some limitations inherent to their mechanical nature, due to the lack of muscles, ligaments, nerves, emotional and biological factors, aspects related to living beings and proprioceptive memory; these limitations should be taken into account to avoid mistakes.

When employed by an operator with good technical dexterity, under accurate clinical criteria, skillful hands and good biomechanical knowledge, the articulator is very useful and presents a good work-cost relationship. It may allow time saving, since an apparently complex case may be easy to solve and have a good prognosis after proper mounting and analysis with the SAA.

It has been statistically demonstrated that the SAA is a practical instrument, with proven veracity and fidelity. Its utilization reduces the number of intraoral interventions, since most occlusal adjustments might be performed directly on the articulator.

Its utilization has become fundamental for dental professionals in current practice, since it allows easy achievement of more accurate works without further damage to the stomatognathic system.

2. MATERIAL AND METHODS

The following literature databases were searched: General Science Index, Medline, Pubmed, EBSCO host and CAPES Periodicals. Studies were selected if they scope were directly related to semi-adjustable articulators. Studies published from 1910 to 2012 were included according to the author's analysis. The keywords of this study were utilized to the consult the databases.

3. LITERATURA REVIEW

Villa (1952)[1], recounts in his book, the emergence of the first models of articulators, according to it, Ga-

riot, in 1805, was the first author to articulate maxillary and mandibular dental casts to maintain the vertical dimension of occlusion. This author also introduced the guiding planes to record the vertical dimension of occlusion. Evan, in 1840, presented a type of articulator that was able to reproduce lateral mandibular movements, with a mobile lower member and fixed upper member. Bonwill, in 1858, described the mandibular condyle movement in horizontal, postero-anterior direction during mouth opening. This author presented a type of articulator that reproduced the lateral mandibular movements together with the horizontal condylar movement. Walker, in 1896, demonstrated the theory of condylar movement during mouth opening, timely correcting the mistake of Bonwill (1858). According to Walker, the condyle presented forward and downward displacement during mouth opening, following the inclination of the glenoid cavity. His anatomical articulator was able to reproduce these movements. Snow, in 1900, introduced the facebow for utilization with the articulator, with a view to transfer the guiding planes from the patient's mouth to the articulator, following the condyle-incisor distance.

Gysi (1910)[2], invented a unique articulator, which had a device adapted incisal guide. This instrument was very advanced for the time, and presented as a novelty the possibility of extra-oral records, however this articulator was not well accepted by professionals of the time, so the surging Gysi Simplex.

Marchetti *et al.* (1980)[3] assigned the term "mechanical examination" to the analysis of dental casts mounted on SAA, defining it as the mounting of maxillary and mandibular dental casts in an appliance that reproduces the mandibular movements. This procedure is fundamental for treatment planning, since it allows the analysis of opposing teeth and the efforts applied to them.

Tamaki (1981)[4] stated that the SAA reproduces the mandibular movements with nearly complete accuracy and thus are the most indicated in Dentistry, due to the need of short chair time to adjust it.

Motsch (1985)[5] states that premature contacts may not be detected by direct occlusal analysis on the patient's mouth, especially if these contacts involve teeth with mobility, which may be displaced or intruded; conversely, on the SAA, these contacts are more evident due to the rigidity of dental casts.

According to Posselt (1981)[6], Santos (1996)[7], Mezzomo (1994)[8] and koyano (2012)[9], successful diagnosis and treatment depend on the good sense and dexterity of dental professionals. The SAA is employed as an auxiliary tool and may only be successfully used if the dental professional is familiarized with the principles of occlusion and mandibular recording.

Ash & Ramfjord (1987)[10] mentioned that the articulator is a mechanical instrument used to connect maxillary and mandibular dental casts of patients, so as diagnostic and restorative procedures may be conducted without the presence of the patient.

According to Stiz (1994)[11], the non-utilization of dental casts mounted on SAA as an auxiliary tool for diagnosis may impair the analysis and conclusions on the oral health status of the patient. This occurs because the teeth are dynamic organs closely related with the soft tissues, bones, joints and ligaments; they also reflect the general health status of the patient.

Fonseca (1994)[12] highlights that "*patients with severe craniomandibular dysfunction are often submitted to general dental treatments without diagnosis of their condition by the dental professional*".

According to Koyano (2012)[9], the SAA is a mechanical appliance that allows adaptation of maxillary and mandibular dental casts of patients, with simulation of the temporomandibular junction and reproduction of some mandibular movements that are fundamental for satisfactory occlusion.

Starcker (2010)[13], reported some advantages of the SAA, including the possibility to reproduce mandibular movements without interference from the neuromuscular system; general visualization of teeth and adjacent structures, especially at the region of second molars, which are often difficult to observe in the presence of soft tissues. However, this author highlights that mounting of dental casts should be careful to allow accurate reproduction of the patient's status.

Souza *et al.* (2001)[14] mentioned the low quality of Wip-Mix (SAA) articulators, whose pieces and components are fabricated with plastic, which often leads to fracture of components due to the low quality of the material and insufficient quality control during fabrication.

Lopes *et al.* (2003)[15] stated that accurate transfer of maxillomandibular relationship from the patient to the articulator depends on several variables, especially the type of articulator employed, technique adopted to transfer the spatial positioning of the maxillary dental cast to the articulator, ability and experience of the operator, accuracy of materials and recording technique, besides the type of material and technique employed for fixation of dental casts to the upper and lower members of the articulator.

Amorin *et al.* (2004)[16] described that patients receiving complete dentures fabricated with aid of articulators report greater comfort and increased masticatory efficiency, better adaptation to the new dentures, and reduced occurrence of soft tissue lesions.

Mounting of dental casts on SAA allows the achievement of several data, such as clear observation

of edentulous spaces and their extent, occluso-gingival height, dental arch curvature, postero-anterior view of dental casts, absence or presence of muscles and ligaments, which may not be noticed during clinical examination of the patient.

The utilization of SAA provides easy observation and treatment planning, allowing the dental professional to perform an assay outside the mouth, foreseeing the probable diagnosis and significantly reducing the risk of iatrogeny.

It should be remembered that the SAA is a valuable instrument for dental professionals, yet it is not a miraculous and failure-proof tool; thus, the possibilities of utilization depend on the professionals handling and caring for this instrument.

Classification of articulators

According to Weinberg (1963 apud TAMAKI 1981[4]), the articulators may be classified into four categories: arbitrary, positional, semi-adjustable and fully adjustable.

- The arbitrary articulator is based on the theories of Monson or Hall. The mobile member is connected to the body by a central point, which allows pendular movements of the member;
- The positional articulator is based on the theory of immutability of vertical dimension. It is characterized by the independence between the upper and lower members.
- The semi-adjustable articulator allows the following adjustments: inclination of condylar path, Bennett angle and incisal path. These articulators include the Gysi, Trubyte and Hanau model H.
- The fully adjustable articulator allows the following settings: inclination of condylar path, Bennett angle, Fischer angle, incisal path, height of pints and intercondylar distance (examples: articulators of Stuart and Di Pietro).

The articulators may be classified as non-adjustable (NAA), fully adjustable (FAA) and semi-adjustable (SAA). The non-adjustable articulators include the simple hinge articulator, the verticulator and the correlator, whose movements and characteristics do not allow reproduction of mandibular movements. One limitation of the simple hinge articulator is the impossibility of lateral movement, associated with an incorrect path of opening and closure compared to the mandible, leading to altered positioning of cusps and consequently to the occurrence of premature contacts when the restoration is placed in the mouth.

These non-adjustable instruments may be employed for single-tooth restorations, in which occasional occlusal changes in the prosthesis may be corrected directly in the patient's mouth, without damage to the chair time and quality of the prosthesis. Thus, the SAA and FAA are better recommended for mounting of dental casts or fabrication of extensive prostheses.

The verticulator and correlator only allow movements in vertical direction; the verticulator is used for mounting of partial dental casts, whereas the correlator may be used with full dental casts.

The advent of FAA was based on the concepts of Gnathology, which considers the reproduction of all mandibular movements as fundamental in prosthodontics. These articulators are able to reproduce all determinants of occlusal morphology and thus allow the achievement of prostheses that are more compatible with the actual status of the patient. This is very important to reduce the chair time required for occlusal adjustment of prostheses.

The problem with the acceptance of FAA is related to the complex mounting and high cost of these articulators. Therefore, due to the appearance and optimization of SAA, its utilization has been reduced, even though it is recommended by many clinicians and researchers.

The SAA, whose initial prototype was the Whip-Mix articulator, is able to partially reproduce the determinants of occlusal morphology. Therefore, they present limitations when compared to the FAA; however, these limitations may be compensated for and thus the prostheses fabricated with aid of SAA are compatible with those achieved with aid of FAA. This fact, combined to the simple mounting, has currently made the SAA the instrument of choice for most cases. As mentioned by Shavel, "*a dentist can do a full-mouth rehab case on a semi-adjustable articulator as long as he has a fully adjustable brain*".

Such SAA may also be divided into ArCon (condyles on the lower member, e.g. Whip-Mix, Denar, Bio-Art, Gnatus, etc.) or non-ArCon (condyles on the upper member, e.g. Dentatus, Hanau).

Articulator parts

Body – central portion to which the members are fixated. Its function is to establish the bicondylar distance and the distance between the members.

Members – horizontal extensions on which the mounting guides and plates are fixated.

Condylar balls – represent the condyles, with small, medium or large intercondylar distance.

Angulation of the glenoid cavity roof – guides the protrusion movements of the articulator.

Condylar housing – guides the protrusion movements of the articulator.

Incisor table – located at the anterior portion of the lower member; provides support to the incisal pin.

Incisal pin – is supported on the incisal table and

maintains the height between the members.

Mounting plates – receive application of plaster for fixation of dental casts to the articulator.

Facebow – accessory device employed for mounting of the maxillary dental cast in the articulator and establishment of intercondylar distance (S, M, L).

Nose piece – stabilizes the assembly on the basis of the Nasion point (glabella).

Bitefork – Allows registration of indentation.

Working positions: centric relation (CR) and maximum intercuspation (MI)

Before description of the occlusal recording techniques, the position to be adopted for mounting of dental casts on the SAA should be discussed. That is to say, the first step before occlusal recording is the definition of the maxillomandibular position.

Different clinical situations influence the selection of mandibular positioning. Thus, it may be stated that the main factor for selection of positioning would be the occlusal stability.

When fixed dentures or single-tooth restorations are fabricated and there is occlusal stability, the maximum intercuspation position (MI) of the patient may be considered for recording and for the prosthesis. Recording in MI follows the mechanism of neurological perception of the periodontal ligament of teeth normally occluding at the opposite side. This allows maintenance of the patient's vertical dimension of occlusion and also compensates for some limitations of the SAA.

In fact, in such cases, the best situation would be if recording was unnecessary, i.e. if the occlusal stability of dental casts is enough to eliminate the need of further recording. The dental casts are then directly mounted against each other, after removal of occasional bubbles form the surface of dental casts. This is common in the fabrication of single-tooth restorations and unilateral fixed dentures with stable dental casts. In these cases, the maxillary dental cast is conventionally mounted with aid of the facebow, and the mandibular dental cast is manually positioned in intercuspation against the maxillary dental arch.

After fabrication of the prosthesis and during adjustment in the patient's mouth, the professional should avoid the introduction of "new" premature contacts in centric relation or during mandibular movement. Such contacts should be eliminated only by adjustments on the prosthesis.

On the other hand, in cases of extensive oral rehabilitation, with periodontal problems or loss of occlusion dimension, the occlusal stability may be absent or the occlusion may interfere with the health of the stomatognathic system. In these cases, since the pathologies are directly related with the occlusion, the MI should not be adopted for the prosthesis.

Therefore, these cases require utilization of condylar positioning for establishment of the working position. This condylar position is the centric relation (CR); after being adopted as working position, it should be harmonious with the dental relationship. Thus, if CR is to be adopted as a therapeutic position, occlusal adjustment of remaining teeth is required for achievement of a stable occlusion. This new maxillomandibular position, in which the tooth contacts are harmonious with the condylar position in centric relation (CR), is called "centric relation occlusion (CRO)".

After establishment of the maxillomandibular relationship, two factors should be considered for interoccusal recording: the recording material and the care to be taken to compensate for the limitations of SAA.

Limitations of SAA and their compensations

As previously mentioned, some limitations of the SAA impair the reproduction of all characteristics observed in the temporomandibular joint, which consequently should be acknowledged and compensated for to improve the final occlusal outcome of the prosthesis.

The influence of these limitations is often related with three occlusal aspects: direction of ridges and grooves, cusp height and fossa depth, and conformation of the palatal cavity of anterior teeth.

Several limitations and compensations of SAA are described in the literature, the most important of which will be described in this section.

Shape and angulation of the articular eminence

Limitation: the upper wall of the "mandibular cavity" of the SAA is straight and rigid, whereas this structure in the TMJ is curved. That is to say, only the initial and final positions of mandibular movement are recorded. Therefore, the actual paths of the condyles are not accurately recorded on the SAA. Consequently, carving of the occlusal surface of posterior teeth increases the risk of occurrence of undesirable contacts during mandibular movements.

Compensation: customization of the anterior guidance while the provisional crowns are worn and its transfer to the incisal table on the articulator reduces the possibility of contacts between the posterior teeth during excursive mandibular movements. This customization guides the establishment of cusp height and fossa depth. These clinical procedures are described in the section on provisional crowns.

Recording of intercondylar distance

Limitation: the SAA records only three intercon-

dylar distances (small, medium and large), whereas the patients may present different variations in these distances. According to the determinants of occlusal morphology, this factor is known to influence the direction of ridges and grooves of posterior teeth and the conformation of the palatal cavity of anterior teeth. Thus, occlusal interferences may be incorporated in prostheses if this factor is not compensated for.

Compensation: customization of anterior guidance.

Immediate lateral displacement

Limitation: in many situations, the condyle at the non-working side exhibits mild movement in lateral direction before contacting the medial wall of the mandibular fossa and initiating its downward, forward and inward movement. This characteristic is observed in nearly half of the population and has been called immediate lateral displacement.

In the SAA, the condylar ball is in close contact with the medial wall of the metallic mandibular fossa and thus is unable to reproduce these characteristics.

When present, the immediate lateral displacement may influence the cusp height and fossa depth.

Compensation: customization of anterior guidance. Prostheses with metallic occlusal surfaces may be submitted to surface treatment with aluminum oxide sandblasting before provisional cementation; this procedure allows the identification of occasional interferences, which will be noticed as shiny spots and should be eliminated before definitive cementation.

Position of mandibular rotation axis

Limitation: the rotation axis transferred to the SAA by the facebow does not correspond to the actual rotation axis present on the condyles. Thus, there may be differences in the opening and closure paths between the articulator and the mandible, which will influence the correct positioning of cusps and posterior teeth in the prostheses.

Compensation: interocclusal recording in vertical dimension of occlusion for mounting of dental casts, or occlusal recording with minimum thickness for dental casts mounted in centric relation.

Materials employed

The materials most commonly employed for intermaxillary recording include waxes, addition and condensation silicones and acrylic resin.

For mounting of dental casts in centric relation, wax or addition silicone may be employed for intermaxillary recording, since these cases require a mild separation between the teeth to record only the condylar position. On the other hand, resin copings are preferable for intermaxillary recording for dental casts mounted in vertical dimension of occlusion.

Recording techniques for study and working casts

The utilization of articulators aims to simulate the mandibular movements and reduce the time spent for intraoral adjustment of prostheses. However, the clinical relevance of articulators is directly associated with the accuracy of interocclusal relation of dental casts mounted on the articulator. When mounting of dental casts on the articulator does not correspond to the occlusal relation of the patient, there will be little benefit from its use. Thus, the ability of professionals to mount the dental casts has more influence on the final quality of the restoration than complete setting of semi-adjustable articulators. Besides saving chair time, more accurate records reduce the possibility of restorations without occlusal contact or requiring excessive adjustment. However, some discrepancy in interocclusal recording is expected, related both to the materials employed and to the several clinical difficulties. Despite of that, these errors should be reduced by careful selection and achievement of recordings among the several methods and materials available for that purpose.

Mounting of study casts on SAA

Since the main semi-adjustable articulators commercially available are similar to the Whip-mix, description of the technique for mounting of dental casts will follow the rules established for this type of articulator; they may also be adapted for application with other articulators.

Mounting of maxillary cast with facebow

The facebow allows mounting of the maxillary dental cast on the SAA at the same spatial positioning of the maxilla in relation to the skull. It also allows transfer of the patient's intercondylar distance and rotation axis of the condyles to the articulator.

Assunção *et al.* (2000)[17] reported that the operator influences the final outcome of mounting of maxillary dental casts on the articulator. The possible occlusal changes induced by the professional when mounting the maxillary dental cast on the articulator are not very relevant in the fabrication of complete removable dentures, since they act as a unit supported by resilient mucosa. The errors produced during mounting and transfer of the maxillary dental cast to the articulator with aid of an arbitrary facebow are related to the inherent limitations of the appliances and techniques, as well as to the inability of the operator to use these instruments.

The facebow is positioned by placing the bite-fork in the patient's mouth with three portions of low fusing impression compound, being one at the anterior region and two at the posterior region. The bite-fork is

placed in the patient's mouth with its handle following the patient's facial midline, molding only the cusp tips and incisal edges of maxillary teeth. After cooling of the impression compound, the bite-fork is removed, the molding is checked and the excess impression compound is removed, maintaining only the areas with molding of cusp tips, to allow complete seating of the dental cast. If this does not occur, these moldings may be enhanced with zinc oxide-eugenol paste or similar materials.

The bite-fork is placed in the mouth and should be stabilized during placement of the facebow. For that purpose, three portions of low fusing impression compound are also placed on the lower portion of the bite-fork, so that the mandibular teeth may keep it stable. Cotton rolls or the patient's hands may also be helpful for this purpose. The facebow is then positioned and connected to the bite-fork handle, keeping them closer. Following, the ear pieces are introduced in the patient's external ears; the patient is asked to keep the position of the facebow by applying a gentle forward and upward pressure with the hands, to keep it as close as possible to the condyles. The third point of the facebow, namely the nose piece, is then fixated to the transverse bar of the facebow. At this step, the intercondylar distance is classified as small, medium or large, as indicated on the frontal portion of the facebow by the letters S, M, L, or by the numbers 1, 2, 3, depending on the brand of articulator.

The facebow is removed by loosening the central screw at the center of the transverse bar and asking the patient to slowly open the mouth.

For mounting of the maxillary dental cast on the articulator, the condylar balls simulating the condyles of the TMJ present three positions for mounting, according to the intercondylar distance established by the facebow. Adjustment is performed by utilization of spacers on the condylar guidance: no spacer for the small, one spacer for the medium, and two spacers for the large intercondylar distance. The chamfered aspect of the spacer should be turned toward the condylar guidance.

After screwing the mounting plate to the upper member of the articulator, the facebow is positioned against the articulator body with one hand and held by the other hand; the rods on the external aspects of condylar guidance are placed in holes in the ear pieces and the pin is tightened. For mounting of the maxillary dental cast, the pin should be removed from the upper member of the articulator and the dental cast is positioned following the molding of cusp tips on the bite-fork, to avoid its vertical movement.

The dental cast is fixated to the mounting plate with a small amount of special plaster complemented with stone; the facebow is then removed and the incisal pin is placed with the rounded end contacting the incisal table, keeping the upper member against the lower member.

Zanetti & Ribas (2001)[18] developed a transfer tray in an attempt to simplify and improve the accuracy of mounting of the maxillary dental cast on the articulator. This allows transfer of maxillary arch recordings to the articulator in a single step, without the need of recording bases and guiding planes, by utilization of the bite-fork associated with the tray, in which molding is achieved and transferred by the tray on the facebow.

Mounting of mandibular dental cast and recording of CR

Since the centric relation (CR) is a craniomandibular position not related with the teeth, recording of this position should be achieved with the teeth separated as minimally as possible, to compensate for the first limitation of the SAA.

This is facilitated by direct placement of a chemically cured acrylic resin jig in the mouth, involving the maxillary central incisors and extending up to 2 cm in palatal direction; this jig aims to release the memory of mechanoreceptors in the periodontal ligament and thus enhance the mandibular manipulation in centric relation. The teeth should be lubricated with petroleum jelly or isolated with aluminum foil to avoid the adhesion of resin on them; the resin should be placed during the plastic phase and the mandible should be guided into centric relation position during polymerization.

After finishing, the jig should be stable and present only one contact point with only one opposing tooth, allowing minimum separation of posterior teeth.

Accorsi (2001)[19] described the utilization of acetate sheets (leaf gauge) to help in mandibular positioning in CR. Since then, due to its simplicity, this technique has been diffused and is currently widely employed for achievement of interocclusal recording and accomplishment of occlusal adjustment. It has been used not only for oral rehabilitation, such as by orthodontists and prosthodontists, but also in undergraduate and graduate courses in Dentistry. This author reported that the variations among operators observed in this technique suggest that its validity is doubtful and that the operator should be intensively trained, especially for mandibular manipulation, thus demonstrating its limitation for the achievement of a true, stable mandibular centric relation. The method described by Long comprises placement of acetate sheets (leaf "gauge") in sufficient number to separate the posterior teeth.

Santos (1996)[7] described that Dawson's bilateral manipulation method would be the most recommend-

ed. In this technique, the thumbs are placed on the patient's chin and the other fingers are placed under the mandibular base. The patient is placed in supine position with the professional behind the head; the professional then stabilizes the patient's head against the abdomen and guides opening and closure movements.

The teeth should gently press the mandible upwards, so that the condyles are more superiorly positioned against the articular eminence, with the articular disc interposed between these structures; the movement should be slow, gentle and no greater than 2 cm, allowing the condyles to perform only the rotation movement. During manipulation, the patient should not feel any symptoms in the temporomandibular joint; if this occurs, the pathology should be treated before the procedures for centric relation recording are conducted.

Jankelson & Radke (1978)[20] mentioned that simple mandibular manipulation into centric relation without any concern with the tension and stress applied on the neuromuscular elements of the stomatognathic system is an improper procedure, since muscle relaxation is a pre-requirement for achievement of a comfortable occlusal position for the patient, consequently keeping the relaxation and harmony of muscles.

When the mandible is manipulated into centric relation without utilization of the jig, the first tooth contact corresponds to the centric relation position. If the operator presses the mandible beyond these contacts, it will slide in anterior and/or lateral direction up to maximum intercuspation. The first centric contact should be identified with acetate and articulating paper, to check the accuracy of mounting of dental casts in CR.

Recording is obtained with softened wax, addition silicone or chemically cured acrylic resin in the mouth; it is then placed on the maxillary dental cast and the mandibular dental cast is positioned against the recording with the articulator turned upside down; both should be joined with elastics or wood sticks fixated on the dental casts with low fusing impression compound or sticky wax.

At this stage, the incisal pin should be increased in 1 to 2 mm to compensate for the thickness of recording; the incisal pin is then unscrewed after stone setting, allowing the teeth to occlude in centric relation position, with the upper member of the articulator parallel to the lower member.

During mounting of dental casts in centric relation, the condylar balls should be correctly and passively placed in the condylar guidance, i.e. at the intersection between the lateral and posterior walls; to avoid this, the condylar balls may be locked by tightening the screw of the lateral rod of the condylar guidance, moved in opposite direction.

After stone setting, the guidance should be set to average values, i.e. 30º for antero-posterior inclination and 15º for the Bennett angle. So far, no scientific studies have demonstrated that customization of these guidance might be more beneficial to the final outcome of prostheses than setting to average values.

After mounting of dental casts on the SAA, the most important step is to check the agreement of occlusal contacts in centric relation position between the dental casts and the mouth. For that purpose, the teeth presenting contacts in this position are initially checked with aid of acetate sheets and identified with articulating paper. These procedures are then repeated in the mouth; if there is no agreement, recording and mounting on the articulator should be repeated.

Mounting of dental casts in centric relation position on the SAA is then completed, with a view to enhance the visualization of maxillomandibular relationship and analyze the presence of premature contacts and mandibular deviation in lateral and/or anterior direction.

4. CONCLUSION

Several authors highlight the importance of utilization of articulators in dental practice.

Dental professionals should always make use of articulators in cases of extensive oral rehabilitation, since this may interfere with the mastication of patients and cause even greater damage, instead of solving any existing problem.

The increased experience with utilization of this appliance increases the technical skills, facilitating the diagnosis of occasional problems that might remain undiagnosed by the dental professional if only clinical oral examination was performed.

Due to the several types of articulators commercially available, dental professionals should select their appliances on the basis of suitability to their needs and easy handling; also, the manufacturer's instructions should be followed for achievement of all benefits provided by these appliances.

Considering these facilities, and the rich information provided by SAA, in many cases its utilization is fundamental for treatment planning, allowing assessment, establishment of the probable prognosis and significant reduction in the risk of iatrogeny. However, according to Posselt (1981)[6], Santos (1996)[7], Mezzomo (1994)[8] and Tannmala (2012)[21], successful diagnosis and treatment depend on the clinical criteria and dexterity of dental professionals. The SAA is an auxiliary tool and may only be successfully applied if the professional is familiarized with the principles of occlusion and mandibular recording.

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