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TENTACÂNULA: INOVAÇÃO FUNCIONAL NA ODONTOPEDIATRIA

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Dissertação apresentada ao Programa de Pós-Graduação em Odontologia da Universidade de Uberaba como parte dos requisitos para obtenção do título de mestre em Odontologia, área de concentração: Clínica Odontológica Integrada.

Orientadora: Profa. Dra. Maria Angélica Hueb de Menezes Oliveira.

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Área de concentração: Clínica Odontológica Integrada

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DEDICATÓRIA

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RESUMO

O presente estudo de inovação tecnológica descreve o desenvolvimento de uma nova versão da tentacânula para Odontopediatria, visando melhorar o conforto do paciente e facilitar a aspiração de fluidos durante os procedimentos odontológicos. O novo design foi projetado para ser mais ergonômico e eficiente, contribuindo para uma experiência mais tranquila tanto para o paciente quanto para o profissional. A tentacânula foi criada em três tamanhos diferentes, possibilitando seu uso em diversas situações clínicas para procedimentos de frenectomia. A principal inovação desse modelo é o design que permite o acoplamento de um sugador, melhorando a funcionalidade e a praticidade. O desenvolvimento do protótipo seguiu uma abordagem estruturada, começando com a criação de um desenho inicial em software AutoCAD e convertido em arquivo SLT para a impressão 3D (tridimensional) por método de modelagem por difusão fundida (FDM). Foram impressos 3 produtos em tamanhos distintos, modificando a largura e comprimento da base, assim como a parte intermediária (área de apreensão do freio lingual) e o cabo. Os produtos foram impressos usando filamento PLA (ácido poliláctico) reforçado com fibra de carbono, com a parte lúdica da tentacânula (tipo “patinho”) apenas em PLA. Os protótipos produzidos foram testados e avaliados, sendo possível verificar sua funcionalidade, destacando as possíveis melhorias ergonômicas e estéticas realizadas a partir da simulação em um macromodelo da cavidade bucal de um bebê com anquiloglossia. Pode-se concluir que o desenvolvimento da tentacânula funcional, tanto no design quanto no material utilizado, mostrou potencial para manter a funcionalidade, melhorar a ergonomia e o aspecto visual, resultando em um instrumento que não só aprimora a experiência do paciente, mas também oferece uma opção mais econômica e inovadora para os profissionais de Odontopediatria.

Palavras-chave: Amamentação. Anquiloglossia. Frenectomia Oral. Inovação. Recém-nascido.

ABSTRACT

This technological innovation study describes the development of a new version of the groove director for pediatric dentistry, aiming to improve patient comfort and facilitate fluid aspiration during dental procedures. The new design was created to be more ergonomic and efficient, contributing to a better experience for both the patient and the professional. The groove director was created in three different sizes, allowing its use in various clinical situations for frenectomy procedures. The main innovation of this model is the design that allows the attachment of an aspirator, improving functionality and practicality. The development of the prototype followed a structured approach, starting with the creation of an initial drawing in AutoCAD software, which was then converted into an SLT file for 3D (three-dimensional) printing using the Fused Deposition Modeling (FDM) method. Three products were printed in different sizes, modifying the width and length of the base, as well as the intermediate part (lingual frenulum grip area) and the handle. The filament used for printing was carbon fiber-reinforced PLA (polylactic acid), with the playful part of the groove director (the "duckling" type) made using regular PLA filament. The produced prototypes were tested and evaluated, allowing the verification of their functionality. Notably, ergonomic and aesthetic improvements were observed from the simulation in a macro model of the oral cavity of a baby with ankyloglossia. It can be concluded that the development of the functional groove director, both in design and material, has shown the potential to maintain functionality, improve ergonomics, and enhance the visual appearance. Therefore, the resulting prototype is an instrument that not only enhances the patient experience but also offers a more economical and innovative option for pediatric dentistry professionals.

Keywords: Breastfeeding. Ankyloglossia. Oral Frenectomy. Innovation. Newborn.

SUMÁRIO

1 INTRODUÇÃO

O frênulo lingual é uma estrutura remanescente do tecido embrionário que, no período fetal, conecta a parte inferior da língua ao assoalho da boca. Com o tempo, ele é quase totalmente reabsorvido, restando apenas uma prega vertical de membrana mucosa que se estende desde a linha média da parte anterior da língua até o assoalho bucal (MILLS *et al.*, 2019; COSTA-ROMERO *et al.*, 2021). Sua principal função é manter os lábios e a língua em alinhamento com os ossos faciais durante o desenvolvimento fetal, controlando assim os movimentos da língua (O'SHEA *et al.*, 2017; COSTA-ROMERO *et al.*, 2021).

O termo anquiloglossia é derivado da palavra grega *"agkylos glossa"* que significa "língua ancorada", ou seja, frênulo curto. Esta é uma anomalia congênita caracterizada por um frênulo anormalmente curto, o que pode limitar a mobilidade da língua em um grau variável, dependendo do seu comprimento, elasticidade e grau de inserção (MESSNER *et al.*,2000; JAMILIAN, FATTAHI e KOOTANAYI, 2014; MECARINI, FANOS E CRISPONI, 2020).

A anquiloglossia pode ser observada em neonatos e bebês, bem como em crianças e adolescentes, mas em alguns pacientes não há o diagnóstico, apesar dos possíveis problemas anatômicos ou funcionais associados (TSAOUSOGLOU *et al.*,2016; MESSNER *et al.*,2020).

A apresentação clínica da anquiloglossia sintomática no paciente infantil inclui amamentação dolorosa, incapacidade de manter a pega de maneira eficaz e, consequentemente, baixo ganho de peso (FERRÉS – AMAT *et al.*,2017). A grande maioria dos bebês com frênulo lingual curto consegue mamar sem dificuldade, porém problemas relacionados à amamentação foram relatados com mais frequência entre bebês com anquiloglossia (MESSNER *et al.*,2000; O'SHEA *et al.*,2017; ROSI-SCHUMACHER *et al.*,2024).

Desse modo, o método mais comum para corrigir a anquiloglossia é pela excisão cirúrgica dos anexos frênicos anormais, como a incisão cirúrgica com bisturi, eletrocautério, ou lasers para tecido mole são as comumente utilizadas para frenectomia lingual. Embora seja um procedimento simples, a localização anatômica e a topografia do tecido lingual o tornam vulnerável a complicações intraoperatórias, como risco de lesão de glândulas salivares e das estruturas anatômicas da própria língua, e pós-operatórias como hemorragias, dor e infecções que são inerentes a todas as cirurgias (JOHNSTON e SHETTY, 2013; VARADAN *et al.*,2019)

Nesse contexto, a frenectomia a laser surge como uma alternativa que reduz a probabilidade de sangramento e de necessidade de sutura da ferida, além de reduzir o tempo operatório e o consumo de analgésicos (MURIAS *et al.,*2022). Os lasers não são apenas viáveis, mas também uma alternativa mais atrativa quando comparada a outras tecnologias disponíveis para frenectomia lingual. As propriedades específicas do laser favorecem um procedimento seguro, rápido e eficaz. Portanto, os pais mais resistentes às recomendações cirúrgicas tendem a reconsiderar o procedimento quando informados sobre as vantagens do laser tanto durante quanto após a cirurgia (SANTOS RODRIGUES, AZEVEDO, 2024).

As crianças requerem um atendimento diferenciado em comparação aos adultos, e a Odontopediatria se destaca como uma especialidade carente em relação ao desenvolvimento de instrumentais específicos, uma vez que a maioria dos utilizados em pacientes infantis é adaptada a partir de modelos destinados a pacientes adultos. Nos últimos anos, observou-se um aumento significativo no diagnóstico de anquiloglossia devido à sua identificação precoce. Consequentemente, um crescimento notável nas cirurgias do frênulo lingual associado à maior conscientização a respeito desse tipo de intervenção para melhorar os problemas relacionados à mobilidade da língua ou dos lábios, como dificuldades de amamentação e fala (JUNQUEIRA *et al*., 2014; WALSH *et al*.,2017; BIN-NUN, KASIRER e MIMOUNI, 2017). Os instrumentais disponíveis não são universalmente adequados a todos os tipos de frênulos, muitas vezes resultando em uma adaptação inadequada na cavidade oral, especialmente em recém-nascidos.

Essa disparidade na oferta de instrumentais específicos para Odontopediatria destaca a necessidade premente de desenvolver ferramentas adequadas e adaptáveis às particularidades da anatomia e das condições bucais infantis. A busca por soluções inovadoras e personalizadas se torna crucial para proporcionar um atendimento odontológico eficaz e confortável às crianças, atendendo às demandas crescentes de diagnóstico e procedimentos cirúrgicos específicos para essa faixa etária (AKTAŞ e CIFTCI, 2024).

Como exemplo de tentativa de atender tal demanda, foi desenvolvido um dispositivo voltado para o público infantil, utilizado como uma capa a seringa carpule, com formato de "jacaré" com o objetivo de distrair a criança durante a realização do procedimento de anestesia (BERTOLDO *et al.*, 2023).

Para isso, há a possibilidade da inovação, que envolve a criação de novas ideias, e a transformação de conceitos intelectuais em produtos ou processos. Mas, para que essas inovações possam contribuir para o crescimento de uma empresa, elas devem ser integradas a atividades comerciais (TROTT, 2012).

A inovação, segundo o Manual de Oslo (2018) pode ocorrer em qualquer setor da economia, incluindo serviços governamentais como saúde e educação. Para o desenvolvimento de novos produtos com direcionamento social desejável, é essencial compreender e assimilar a maneira com que a inovação tecnológica acontece no setor da saúde (CAETANO, 1998).

O avanço tecnológico na área da saúde é influenciado por uma série de fatores interligados, que englobam tanto aspectos científicos quanto econômicos, sociais e regulatórios. As novas descobertas científicas, por exemplo, são fundamentais para impulsionar inovações tecnológicas, como o desenvolvimento de novos dispositivos médicos e softwares (SHEIKH *et al.*,2021).

No entanto, esses avanços só se concretizam com o apoio financeiro dos setores público e privado, além de incentivos fiscais e subsídios, que desempenham um papel essencial na aceleração da pesquisa e no desenvolvimento de soluções inovadoras no setor da saúde.

Apesar dos progressos tecnológicos ocorridos nas últimas décadas, observam-se situações precárias em diversas áreas da sociedade, como acesso à saude, educação, moradia, alimentação e lazer (JACOB, SANCHEZ-VAZQUEZ, IVORY, 2020). Quando se trata da qualidade de vida de pacientes e profissionais, a área da saúde, principalmente no que se refere ao público infantil, apresenta elevado contraste. Essa disparidade é acentuada, pois a indústria de equipamentos médicos não apresenta resultados quanto ao desenvolvimento e pesquisa em produtos para esse público, diferente do interesse demonstrado ao público adulto (AMANTINI, 2014).

Durante o século XVIII, as parteiras utilizavam as unhas da mão para a liberação da língua do recém-nascido, e ao longo do tempo, outros instrumentos foram desenvolvidos para este fim. Atualmente, os instrumentos utilizados assim como as técnicas cirúrgicas foram aprimorados e é possível oferecer um tratamento mais eficiente e confortável para o paciente que apresenta anquiloglossia com indicação de tratamento cirúrgico (WALSH e MCKENNA BENOIT,2019).

A proposta de uma nova tentacânula requer um novo desenho e a partir desse novo design pode se tornar uma oportunidade de soluções e diferencial competitivo para empresas. Um novo design é um importante componente estratégico empresarial e atua como facilitador no processo de inovação auxiliando no desenvolvimento econômico e sociocultural (KRUCKEN, 2009; FRANZATO; CELASCHI, 2017; FARIDA e SETIAWAN, 2022).

Os avanços na tecnologia de impressão 3D (tridimensional) estão proporcionando uma nova direção na Odontopediatria, oferecendo soluções inovadoras para desafios tradicionais. A notável expansão da impressão 3D exige uma análise abrangente de seu uso e aplicações na área odontológica, principalmente no atendimento de pacientes infantis (AKTAŞ e CIFTCI, 2024).

Um material e uma técnica de fabricação apropriados devem ser escolhidos para a representação digital. Este fluxo de trabalho é adaptável a várias tecnologias de impressão e acomoda uma ampla variedade de materiais, incluindo polímeros (ácido polilático, policaprolactona e polieteretercetona (PEEK), metais (aço inoxidável, liga de cobalto-cromo e titânio e liga de titânio) e cerâmica (zircônia) (OBEROI *et al.*,2018, HUANG *et al.*,2022).

A impressão 3D utilizando materiais como fibra de carbono e PLA (ácido polilático) tem ganhado destaque na Odontopediatria devido à sua aplicabilidade em diversas áreas clínicas e laboratoriais. Esses materiais, especialmente quando usados em conjunto com tecnologias de impressão 3D, podem proporcionar soluções inovadoras no tratamento odontológico infantil.

O PLA é um dos plásticos mais utilizados na impressão 3D, especialmente por ser biodegradável e ter uma maior facilidade de uso. Na Odontopediatria, o PLA é utilizado na criação de modelos para planejar tratamentos ortodônticos, restaurações temporárias e guias de tratamento (cirurgias e ortodontia) devido às suas propriedades que permitem uma boa precisão de impressão.

A impressão 3D com a fibra de carbono e PLA permitem a personalização de dispositivos de acordo com as necessidades das crianças, com excelente precisão, além da redução de tempo e custo de produção dos produtos quando comparada com as tentacânulas em metal comercialmente disponibilizadas.

A colaboração entre profissionais de Odontopediatria e a inovação em instrumentais são fundamentais para aprimorar a prática clínica, favorecendo a aceitação das crianças durante o atendimento odontológico. Essa parceria visa não apenas a eficácia clínica, mas também o conforto e a receptividade dos pacientes pediátricos. A abordagem visionária permite repensar e melhorar as ferramentas, proporcionando uma experiência mais positiva para as crianças.

Portanto, essa sinergia entre os profissionais resulta em instrumentos mais eficientes e adaptados às necessidades específicas das crianças, contribuindo significativamente para a melhoria da prática clínica e elevando a qualidade do atendimento odontológico pediátrico.

2 OBJETIVOS

2.1 Objetivo geral

Desenvolver novos designs de tentacânulas para aplicação na Odontopediatria por meio da impressão 3D, fabricada em fibra de carbono reforçada com PLA em três tamanhos diferentes e com um encaixe para integrar ao sugador e um acessório lúdico no cabo do produto. Realizar a proteção de propriedade intelectual: pedido de patente e registro de desenho industrial.

2.2 Objetivos específicos

- Desenvolver três novos designs de tentacânulas;

- Imprimir as tentacânulas de fibra de carbono reforçada com PLA;

- Imprimir o objeto lúdico em PLA;

- Avaliar o desenvolvimento do produto;

- Realizar a proteção de propriedade intelectual.

3 CAPÍTULO 1

Research Article: Biomaterials and Bioengineering in Dentistry

Development of a functional groove director for frenectomy in pediatric dentistry

Concise title: 3D printing of a functional groove director for frenectomy

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4 ABSTRACT

Background: Ankyloglossia is a congenital anomaly in which the lingual frenulum attaches near the tip of the tongue and can affect the child's development and breastfeeding when present in newborn babies. *Objectives:* To develop three new models of groove director for pediatric dentistry to improve patient comfort during the procedure and facilitate the operator's aspiration of fluids due to their innovative design and playful aspect. *Material and Methods*: The cannulas were created in three different sizes, featuring a design that allows the attachment of a suction cup and the creation of a playful accessory. The prototype's development continued from the design's creation to its printing. Initially, the drawing was created for design approval. Then, it was converted into a three-dimensional (3D) model for later printing. The material chosen was carbon fiber-reinforced PLA and regular PLA for the playful object. The groove director was designed to minimize discomfort during use, facilitating its handling and positioning. *Results:* It was possible to verify from the macromodel the apprehension of the lingual frenulum, ergonomics, and change in the visual appearance of the functional groove director. *Conclusion:* The creation of different sizes of the groove director demonstrated the potential to maintain the product's function, improve the ergonomic and visual aspects, and become a passive distraction tool for the child. In addition, conditions were considered to allow manufacturing at a low cost, which is an innovative option for a product widely used in the routine of pediatric dentistry professionals.

Keywords: Breastfeeding. Ankyloglossia. Oral frenectomy. Innovation. Newborn.

5 INTRODUCTION

The Greek word “agkylos glossa”, meaning “anchored tongue,” derives Ankyloglossia, a short frenulum. This is a congenital anomaly characterized by an abnormally short frenulum, which can limit the tongue's mobility to a variable degree, depending on its length, elasticity, and degree of insertion [1,2].

They observe this anomaly in neonates and infants, as well as in children and adolescents, but in some patients, doctors do not diagnose it despite possible associated anatomical or functional problems [3,4]. The clinical presentation of symptomatic ankyloglossia in pediatric patients includes painful breastfeeding, inability to maintain an effective latch, and, consequently, low weight gain [5]. The vast majority of infants with a short lingual frenulum can breastfeed without difficulty, but breastfeeding-related problems have been reported more frequently among infants with ankyloglossia [1,5,6].

Thus, the most common method to correct ankyloglossia is surgical excision of the abnormal phrenic attachments, such as surgical incision with a scalpel, electrocautery, or soft tissue lasers commonly used for lingual frenectomy. Although it is a simple procedure, the anatomical location and topography of the lingual tissue make it vulnerable to intraoperative complications, such as the risk of injury to salivary glands and the anatomical structures of the tongue itself, and postoperative complications such as hemorrhage, pain, and infections that are inherent to all surgeries[7,8].

In this context, laser frenectomy emerges as an alternative that reduces the likelihood of bleeding and the need for wound suturing, in addition to reducing operative time and analgesic consumption [9]. Lasers are viable and a priority alternative among other technologies for a lingual frenectomy. The specific properties of the laser favor a safe, fast, and effective procedure. Therefore, parents more resistant to surgical recommendations tend to reconsider the procedure when informed about the advantages of the laser both during and after surgery [10].

The children require differentiated care compared to adults, and pediatric dentistry stands out as a specialty lacking in developing of specific instruments. In recent years, there has been a significant increase in the diagnosis of ankyloglossia, along with a notable growth in lingual frenulum surgeries [11-13]. Available instruments are not universally suitable for all types of frenulum, often resulting in inadequate adaptation to the oral cavity, especially in newborns

This disparity in the supply of specific instruments for pediatric dentistry highlights the pressing need for professionals to develop appropriate tools that can be adapted to the particularities of children's anatomy and oral conditions. The search for innovative and personalized solutions becomes crucial to providing effective and comfortable dental care for children, meeting the growing demands for diagnostics and surgical procedures specific to this age group [14].

To meet demand, a device aimed at children was developed. It is a case for the carpule syringe in the shape of a crocodile to distract the child during the anesthesia procedure [15].

Advances in 3D (three-dimensional) printing technology provide a new direction in pediatric dentistry, offering innovative solutions to traditional challenges. The remarkable expansion of 3D printing requires a comprehensive analysis of its use and applications in the dental field, especially in the care of pediatric patients [16-17].

The proposal for a new groove director requires a new design, which can become an opportunity for solutions and a competitive advantage for companies. A new design is an important strategic business component and acts as a facilitator in the innovation process, aiding in economic and sociocultural development [18,19].

Collaboration between pediatric dentistry professionals and innovation in instruments is essential to improve clinical practice, favoring children's acceptance during dental care. The visionary approach allows rethinking and improving tools, providing a more positive experience for children.

Therefore, the present study describes the development of groove directors in three different sizes, innovating both in design and material, aiming to improve their ergonomic, applicability, and visual aspects for pediatric patients.

6 MATERIAL AND METHODS

6.1 3D design and drawing

Initially, the groove director design and the 3D drawing were performed using AutoCAD software (Autodesk, 2021) for prototyping. Three drawings of different sizes were created, modifying the dimensions of the base, intermediate area, and handle, respectively (Figure 1A), with groove director “A” - reference, with the exact dimensions as the commercially available instrument (handle: 13.0 cm long; base: 3.0cm x 2.0cm; intermediate area: 1.0 cm). A fitting for a fluid suction device and a 3.5 cm playful accessory was created for the handle (Figure 1B). Once the design creation phase was completed, the file was converted to STL for 3D printing.

6.2 Product development

A prototype was produced on an X1 Carbon 3D printer (Bambu Lab, Shenzhen, China). Once the conditions regarding the shape and size of the groove director were satisfied, printing began. The X1 Carbon printer uses FDM (Fused Deposition Modeling) technology. The characteristics of the 3D printer are described in Table 1. During the FDM process, the plastic filament, in this case PLA (polylactic acid), was melted by a heated nozzle and deposited layer by layer until the three-dimensional object was formed. Carbon fiber-reinforced PLA was used to print the groove director due to its enhanced physical properties (strength, resistance and flexibility) compared to regular PLA, which was the filament used (in the collors yellow, white, and black) for the playful "duckling" device, as shown in Table 2.

After the 3D printing stage, the groove directors were positioned in a macro model representing the oral cavity of a newborn with ankyloglossia to verify the geometric conformation of the product for grasping the lingual frenulum and the ergonomics used by the professional.

7 RESULTS

7.1 Design and 3D drawing

The design and 2D drawing (in the SLT file) are represented in figures 1 and 2, respectively. The dimensions of the groove director (length of the cable and area to grasp the frenulum) were modified. Three different sizes were created, namely: "A" = 13.0 cm cable; 3.0x2.0 cm base and 1.0 cm intermediate region; "B" = 13.4 cm cable; 2.6x2.1 cm base and 1.0 cm; "C" = 13.4 cm cable; 2.6x2.2 cm base and 1.5 cm in the frenulum grasp region. In all models, a fitting for the suction device was created (represented in figure 1 – section A). To improve the visual aspect, a playful accessory was created – "duckling" type (Figure 1 "e").

7.2 Product development

Figure 3A shows the different sizes of the groove director and the playful object after printing. The dimension difference is visible compared to the conventional groove director (Thimon, São Paulo, SP, Brazil) (Figure 3 B). The playful toy "duck" was later attached to the instrument's handle. When checking the geometric conformation of the created groove directors, it was possible to observe the capture of the frenulum and assume the removal of the tongue (Figure 4). In addition, the ergonomics used by the professional, that is, the possibility of working with two hands without the need for an assistant to hold the suction cup since it was placed next to the product's handle (Figure 4B), were noted.

8 DISCUSSION

Many infants with ankyloglossia are asymptomatic, but if left untreated, symptomatic cases can cause functional difficulties with breastfeeding, atypical swallowing, swallowing problems, and poor latch. It can also result in restless infants, failure to gain weight, and dehydration [1-3,6,19].

The prevalence of ankyloglossia ranges from 4% to 10%, depending on the diagnostic criteria used. The incidence of ankyloglossia is said to be approximately 0.2% to 5%, depending on the population studied, and is more common in males [1,20]. The recommendation of the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) is that mothers should breastfeed exclusively for the first six months and, with supplementary feeding, continue to do so until the age of 2 years due to the fundamental role of human milk in the development of the child, being associated with multiple health aspects, such as the prevention of dyadic diseases, oral health conditions, such as better occlusal development, in addition to acting as a preventive measure for social issues [21].

Babies with ankyloglossia had a shorter period of exclusive breastfeeding and a higher risk of weaning when compared to infants with a normal lingual frenulum [22].

For diagnosis, it is essential to combine the morphological identification of a short frenulum with the functional aspects of the tongue, such as its mobility and appearance associated with insertion. The fixation and shortening of the frenulum should also be evaluated [1,2,23,24].

Therefore, clinical protocols are important to assess ankyloglossia, as they allow for the establishment of parameters and help professionals make a correct diagnosis and plan an effective treatment program [25]. In this sense, in 2014, Federal Law No. 13.003 was enacted, making the application of the Spoken Language Assessment Protocol with Scores for Babies mandatory for newborns in all maternity hospitals in Brazil. This protocol can be applied by trained health professionals, including speech therapists and dentists [26].

Treatment of ankyloglossia should be considered at any age, assessing the risk-benefit due to the greater vascularization and mobility of the tongue. Therefore, lingual frenectomy should be performed with fewer traumatic events to avoid postoperative complications [27].

Historically and currently, the primary treatment for ankyloglossia in babies is frenectomy, which involves the surgical division of the lingual frenulum with scissors, with or without prior clamping. Fingers, a retractor, or cotton-tipped applicators can be used to retract the tongue [19,28].

However, using the groove director facilitates the procedure, as it keeps the tongue in a stable position, allowing a better view of the surgical field. In the present study, based on the development of groove directors in different sizes, it was possible to assume that the instrument holds the newborn's tongue towards the roof of the mouth, causing the frenulum to be stretched, facilitating its delimitation and subsequent excision of the tissue to be cut, confirming its function and indication and eliminating the need for four-handed work, since the assistant can act in controlling the child's behavior and not the procedure itself, such as sucking oral fluids with the aspirator.

3D printing technology has established itself as a revolutionary strategy in the dental sector, allowing the creation of new products and personalized solutions with greater efficiency and precision, as presented in this study, since new products have been developed, presenting different dimensions for adaptation to other types of lingual frenulum, creation of support for the suction cup, in addition to visually transforming the instrument with the playful device, becoming a distraction tool for the child. The material chosen for printing is PLA, a thermoplastic polymer made with lactic acid from raw materials that have renewable sources. It can be made from vegetables such as corn, cassava, beetroot, or sugar cane. Because it originates from organic matter, PLA is biodegradable and, therefore, compostable and recyclable, and does not harm the patient or the environment [29].

PLA could become an alternative material for the manufacture of dental instruments. When a laser frenectomy is performed with a metal groove director, light reflection occurs, which requires attention, especially regarding eye protection, both for the professional and the patient.

Moreover, the production of the groove director using an enhanced version of PLA, specifically carbon fiber-reinforced PLA, was essential to obtain a viable prototype due to its improved strength and durability. Previous trials using regular PLA resulted in fragile and easily breakable products, as the required thin and elongated dimensions compromises the material's integrity, thus requiring stronger physical properties[30]

3D printing has proven advantageous, as it allows customization of the groove director, reduces time and cost, and provides good quality and precision after printing.

Although the products created in this study were printed on PLA-based materials, more studies are needed to evaluate their physicomechanical properties and geometric conformation in the baby's oral cavity. Therefore, within the limitations of this study, clinical studies are necessary to evaluate the applicability of the groove director and the acceptability of children and guardians regarding technological innovation.

9 CONCLUSION

The development of groove directors of different dimensions, both in terms of design and material, demonstrated the potential to maintain its functionality, improved its ergonomic and visual appearance, and became a passive distraction tool for the child. In addition, they considered conditions to allow for low-cost manufacturing

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12 CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

Tables

Table 1. 3D printer specifications.

3D printer	Main configurations
X1 Carbon (Bambu Lab, Shenzhen, China)	Technology: Fused Deposition Modeling Maximum speed: 500 mm/s Maximum acceleration: m/s² Maximum hot end flow: 32mm³, 280º C Cooling: Closed loop control Filaments supported: PLA, PETG, TPU, ABS, ASA, PVA, PET Carbon fiber and glass reinforced polymer

Table 2. Specifications of the materials used to print the groove director.

Material	Properties General	Recommended printing configurations
Carbon fiber-reinforced PLA (Shenzhen Tuozhu Technology Co., Ltd.)	Filament type: carbon fiber filling Surface: matt Impact resistance: 23.2kJ/m² Flexural strength: 89 MPa Stiffness (flexural modulus): 3950 MPa Layer adhesion (impact resistance -Z): 7.8 kJ/m² Heat resistance: 55ºC Provides enhanced strength, stiffness, and durability, making it more resistant to wear, impact, and fatigue, compared to regular PLA	Drying settings: rapid drying oven: - 55 °C, 8 h Printing and maintaining container humidity: < 20% RH (sealed, with desiccant) Nozzle temperature: 210 - 240 °C Bed temperature (with glue): 35 - 45 °C Print speed: < 200 mm/s
PLA filament (Voolt3D, Santo André, São Paulo, Brasil)	Easy printing There is no need to close the printer while printing Excellent adhesion between layers Good mechanical resistance to static loading Low shrinkage part No warping Glossy parts/ No strong odors	Raw material: Lactic Polyacid Filament diameter: 1.75mm +/- 0.02mm Extrusion temperature: 190º- 215ºC Table temperature: 50º - 70ºC

Figures

Figure 1. Groove Director design in 3 different sizes. "A" refers to the commercially available product. The lower case letters are: a= base width; b= frenulum grasping region; c= a+b (base); d= product handle; e = play object; f = sucker attachment.

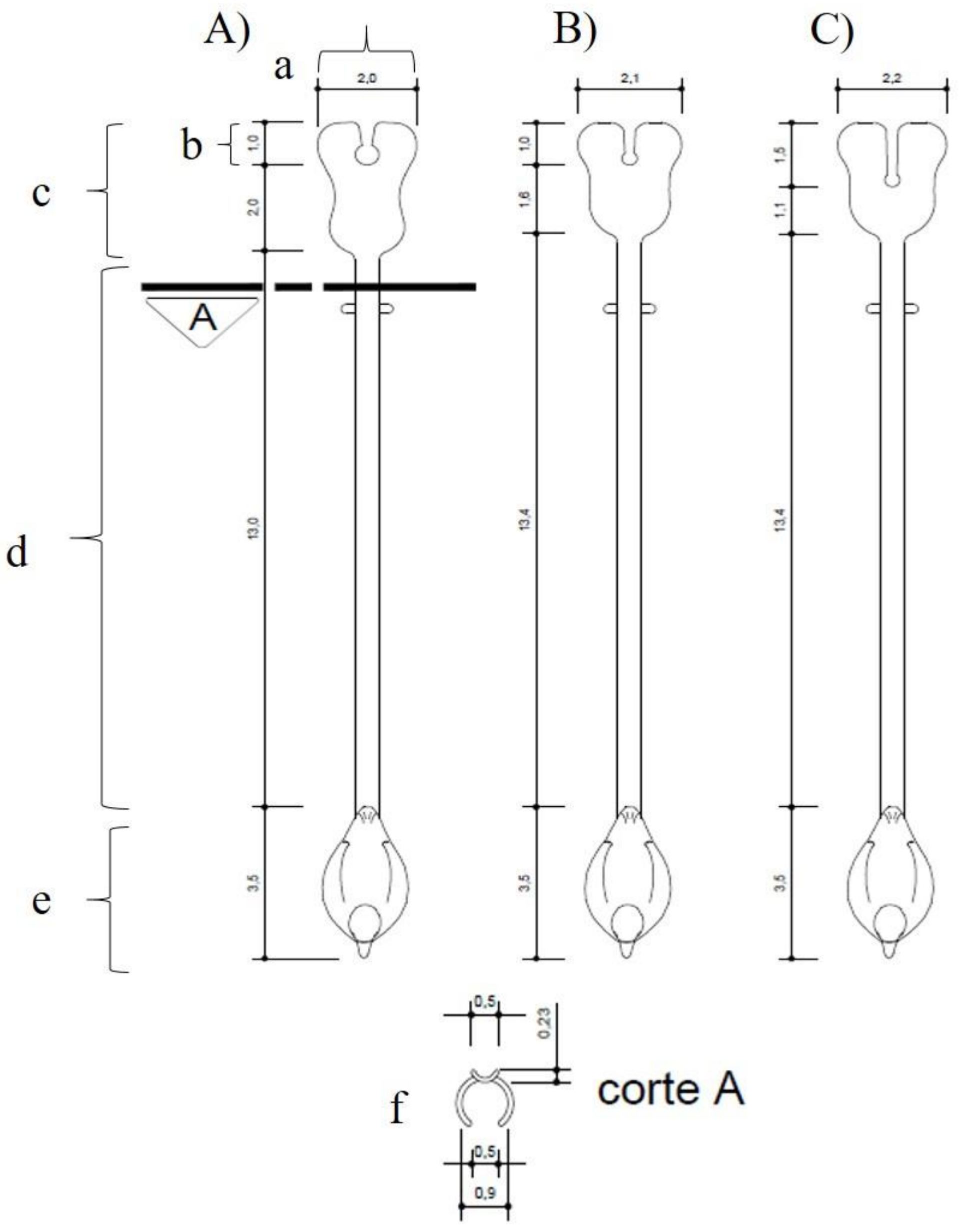


Figure 2. 3D drawing. Virtual modeling of the groove director. A) Different dimensions of the instrument. B) Fitting created for the suction device.

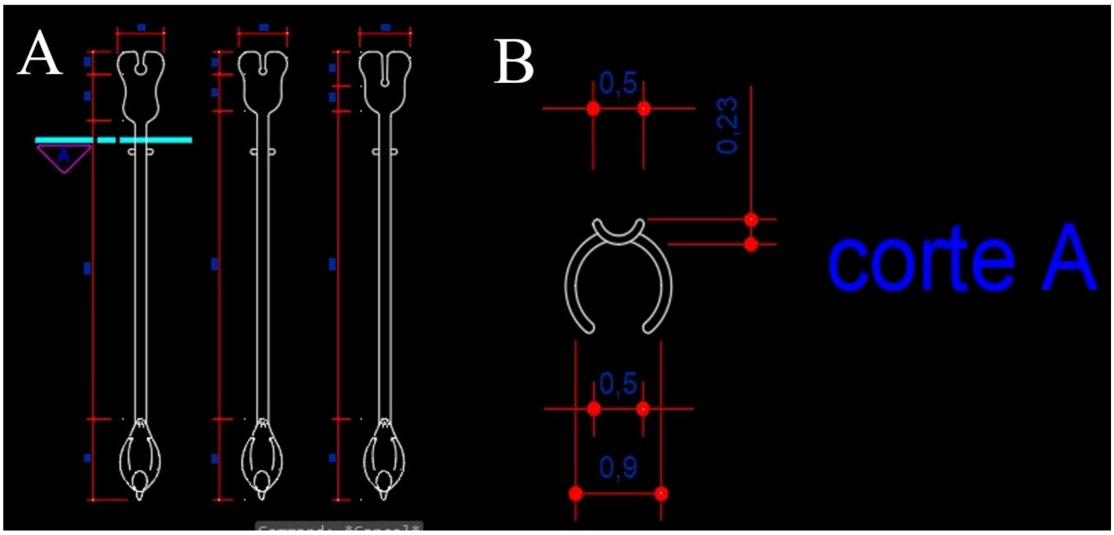


Figure 3: 3D printed tentacles. A) Comparison between the Groove Director created and the conventional one. B) Printed Groove Director and the "duck" toy object.

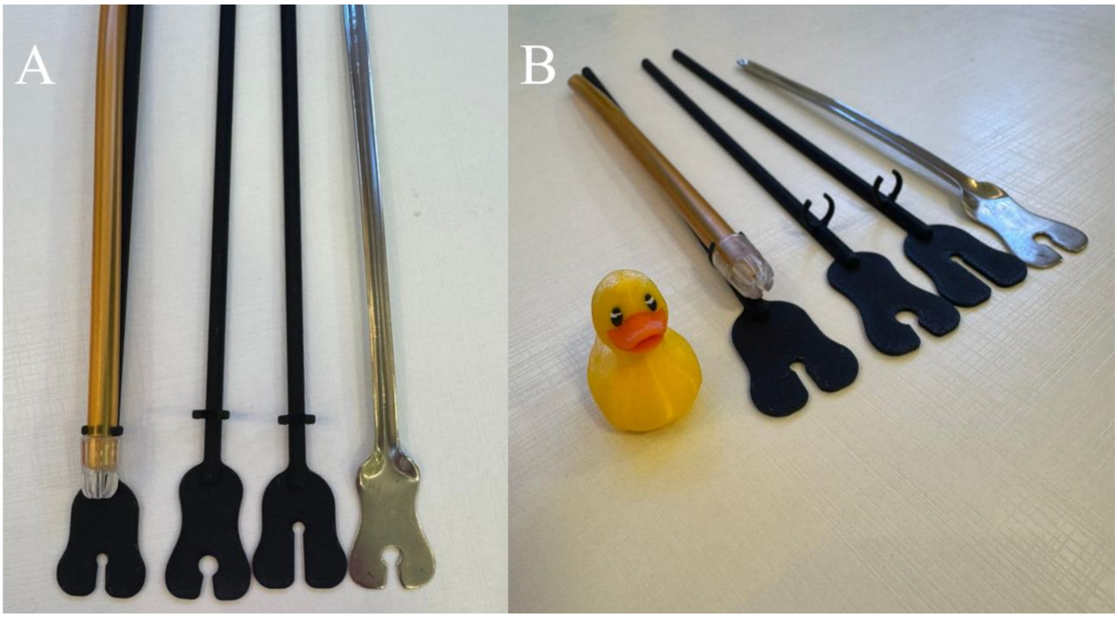
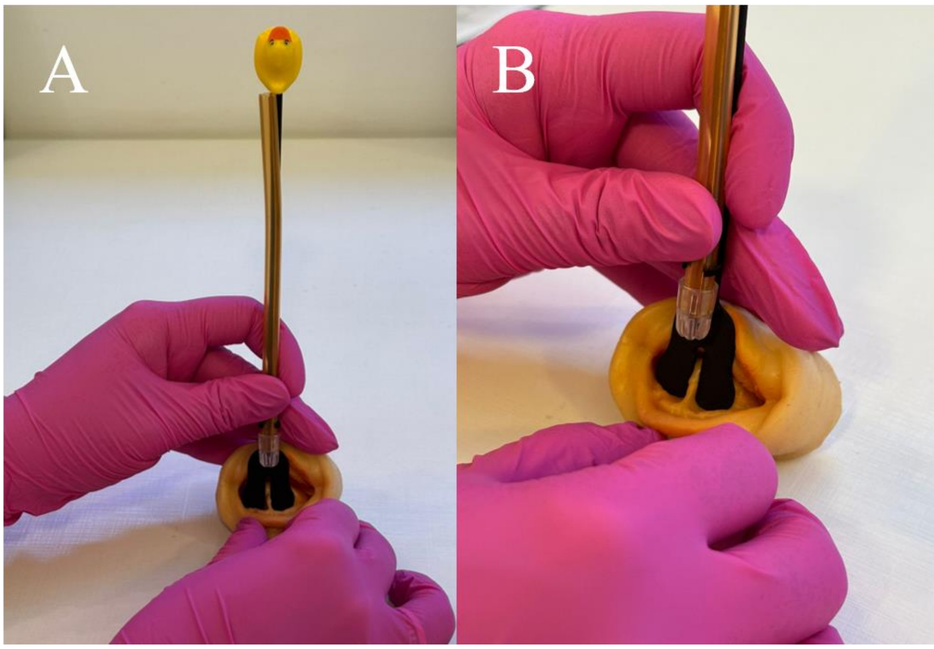


Figure 4: Groove Director created by 3D printing and PLA. A) Groove Director in position, simulating the grasping of the frenulum. B) Operator ergonomics, eliminating the need for 4-handed care.



13 CONCLUSÃO

Pode-se concluir que o desenvolvimento de diferentes modelos de tentacânula, tanto em relação ao design, quanto ao material demonstrou potencial para manter a função do produto, e melhora do aspecto ergonômico e visual o que pode tornar-se uma ferramenta de distração passiva para a criança. Além disso, foram consideradas condições que permitiram a fabricação a um baixo custo.

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ANEXO

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