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Sumário

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JOIS

CASE REPORT

Single-stage management of a longitudinal root fracture associated with extensive bone resorption in the esthetic zone: a case report of immediate implant placement, guided bone regeneration,and immediate provisionalization

RELATO DE CASO

Manejo em estágio único de uma fratura radicular longitudinal associada à extensa reabsorção óssea na zona estética: relato de caso de instalação imediata de implante, regeneração óssea guiada e provisionalização imediata

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Abstract

Longitudinal fractures in endodontically treated teeth, especially after trauma, often present an unfavorable prognosis, associated with pain, fistula, and bone resorption. Immediate implant placement associated with regenerative techniques and immediate loading can offer a predictable solution for esthetic and functional restoration. Case report: A 35-year-old female patient presented with longitudinal fracture of tooth #12 with periapical lesion and fistula. Careful extraction, curettage, and socket decontamination with active oxygen gel (blue®m) were performed. A Helix Acqua GM Neodent implant (3.5 × 16 mm) with 60 N·cm insertion torque was placed, positioned 3 mm subcrestal. A universal abutment torqued at 20 N·cm was adapted, followed by placement of a provisional tooth previously milled in PMMA. The bone defect was filled with bone graft (Straumann® cerabone®)) and covered with a resorbable membrane (Straumann® Jason® membrane), associated with a de-epithelialized connective tissue graft from the palate. Clinical and radiographic follow-up demonstrated fistula resolution, provisional stability, preservation of peri-implant tissues, and favorable esthetic contour. Conclusion: Single-stage treatment combining immediate implant placement, immediate loading, bone grafting, connective tissue grafting, and active oxygen gel proved to be an effective alternative for root fracture cases in the esthetic zone, providing predictable rehabilitation with satisfactory clinical and esthetic results.

Keywords: Dental implants; Bone regeneration; Immediate dental implant loading.

Resumo

Fraturas longitudinais em dentes tratados endodonticamente, especialmente após trauma, frequentemente apresentam prognóstico desfavorável, associadas a dor, fístula e reabsorção óssea. A colocação imediata de implantes, associada a técnicas regenerativas e carga imediata, pode oferecer uma solução previsível para restauração estética e funcional. Relato de caso: Paciente do sexo feminino, 35 anos, apresentou fratura longitudinal do dente 12 com lesão periapical e fístula. Foi realizada extração cuidadosa, curetagem e descontaminação do alvéolo com gel de oxigênio ativo (blue®m)Um implante Helix Acqua GM Neodent (3,5 × 16 mm) com torque de inserção de 60 N·cm foi instalado, posicionado 3 mm subcrestalmente. Um abutment universal com torque de 20 N·cm foi adaptado, seguido da instalação de um dente provisório previamente fresado em PMMA. O defeito ósseo foi preenchido com enxerto ósseo (Straumann® cerabone®) e coberto com uma membrana reabsorvível (Straumann® Jason®), associada a um enxerto de tecido conjuntivo desepitelizado proveniente do palato. O acompanhamento clínico e radiográfico demonstrou resolução da fístula, estabilidade provisória, preservação dos tecidos peri-implantares e contorno estético favorável. Conclusão: O tratamento em estágio único, combinando a colocação imediata do implante, carga imediata, enxerto ósseo, enxerto de tecido conjuntivo e gel de oxigênio ativo, mostrou-se uma alternativa eficaz para casos de fratura radicular na zona estética, proporcionando reabilitação previsível com resultados clínicos e estéticos satisfatórios.

Palavras-chave: Implantes dentários; Regeneração óssea; Carga imediata em implantes dentários.

Introduction

Longitudinal fractures in endodontically treated teeth after trauma are relatively common outcomes, often with unfavorable prognosis, frequently associated with pain, fistula, and localized bone loss[1,2]. In such situations, extraction with immediate implant placement emerges as a predictable alternative to preserve bone and esthetics, especially in the anterior maxillary esthetic region[3,4,5].

To achieve success in these cases, some factors are critical: bone availability, adequate insertion torque for immediate loading[6,7], three-dimensional implant positioning to promote marginal bone stability, tissue stabilization, and future prosthetic crown[8,9,10], decontamination of the infected site, and regeneration of the bone defect with osteoconductive biomaterials and barrier membranes[11,12,13].

The association of connective tissue grafts with immediate implants in the esthetic zone has shown superior results in soft-tissue stability and peri-implant esthetics[14,15,16]. Additionally, antimicrobial adjuvants such as active oxygen gel (blue®m) have been reported as promising in controlling infection and stimulating tissue healing in periodontal and peri-implant regions [17,18,19,20,21].

Performing all these steps in a single surgical stage presents important advantages: reduces the number of interventions, improves patient experience, decreases cumulative infection risks, and accelerates functional and esthetic rehabilitation[22,23].

Immediate provisionalization associated with bone graft and connective tissue grafts promotes soft-tissue healing and preserves gingival contour from the beginning, contributing to long-term stability [24,25]. This integrated strategy allows not only immediate replacement of the lost tooth but also simultaneous reconstruction of hard and soft tissues, ensuring better esthetic and functional outcomes in critical areas [9,10].

Thus, this case aims to report a complete clinical case of longitudinal fracture with periapical lesion in a maxillary lateral incisor, treated in a single surgical stage with extraction, socket decontamination with active oxygen gel, immediate subcrestal implant placement, bone regeneration, connective tissue graft, and immediate provisionalization.

Case Report

A 35-year-old female patient sought dental care reporting local trauma in the region of the maxillary right lateral incisor (#12), followed by pain and recurrent fistula in the area, endodontically treated about 15 years earlier (Figure 1).

Figure 1 – Initial appearance – Fistula above tooth #12.

Clinical examination revealed slight gingival edema and presence of a fistulous tract in the vestibular region of tooth #12. A cone-beam computed tomography (CBCT) showed an extensive periapical lesion associated with external tooth and bone resorption, as well as findings compatible with longitudinal root crack (Figures 2 and 3).

Due to the poor prognosis, surgical treatment with extraction, followed by immediate implant placement and immediate loading associated with regenerative and soft-tissue thickening techniques was indicated.

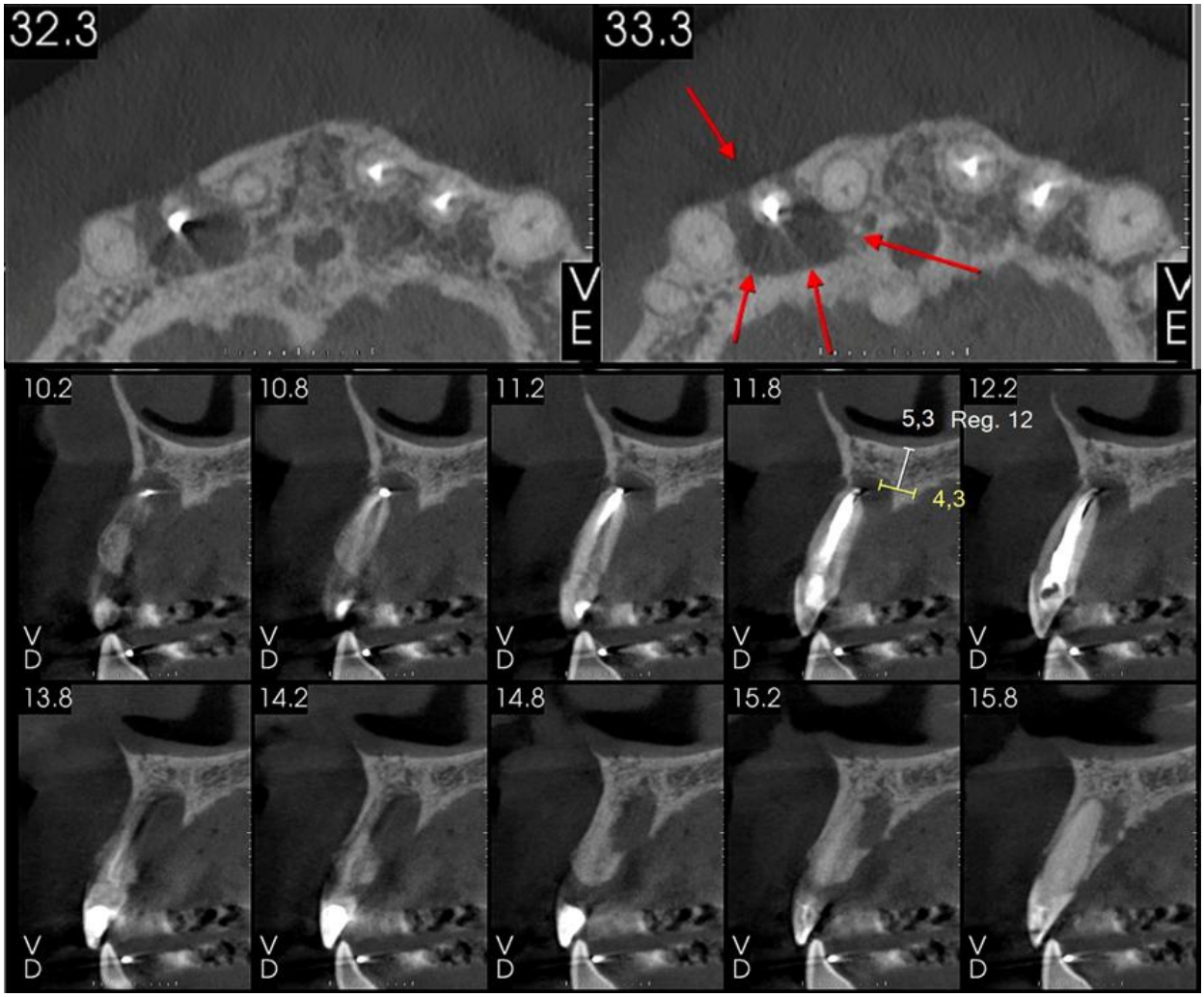

Figure 2 – CBCT – Bone and external tooth resorption of tooth #12.

Figure 3 – 3D reconstruction – Bone resorption and Fracture image of tooth #12.

Antibiotic (Amoxicillin 500mg) therapy was prescribed one week prior to surgery to control infectious exacerbation. After intra- and extra-oral asepsis, local infiltration anesthesia with articaine 4% with epinephrine 1/100.000 was performed, followed by an incision extending from the distal of the canine (#13) to the mesial of the central incisor (#11). A full-thickness flap was raised, and the longitudinal fracture was visualized and confirmed (Figure 4).

Atraumatic extraction was performed, followed by careful curettage and abundant irrigation with sterile solution. The socket was then decontaminated with active oxygen gel (blue®m), applied topically and left for 3 minutes, followed by abundant irrigation (Figures 5 and 6).

Figure 4 – Total flap reflection – Confirmation of fracture.

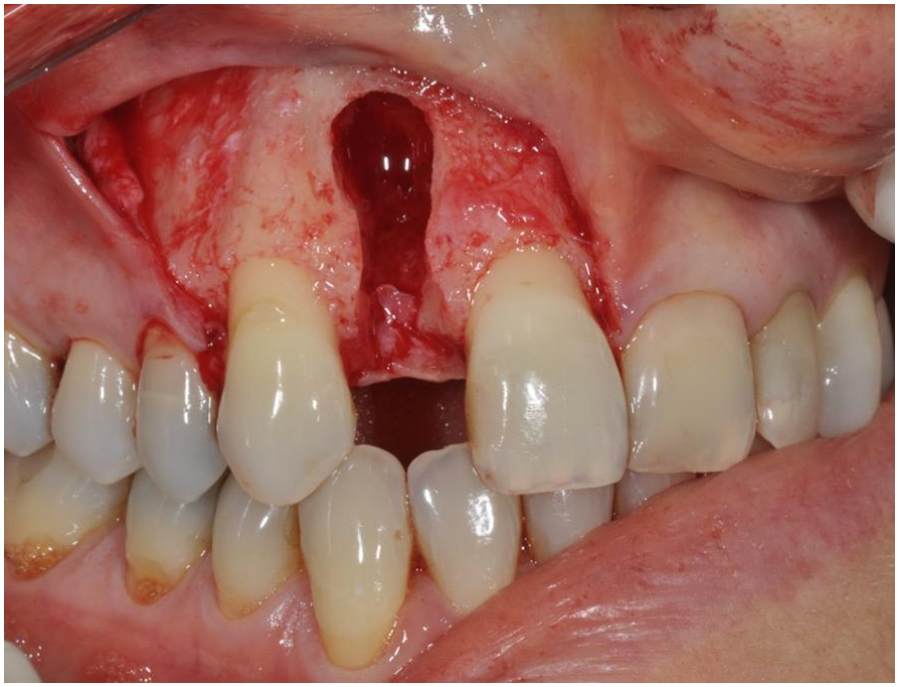

Figure 5 – After tooth removal and curettage.

Figure 6 – Application of blue®m gel in the surgical socket for decontamination.

A Helix Acqua GM Neodent implant (3.5 × 16 mm) was placed with palatal positioning and bicortical anchorage (Figure 7), approximately 3 mm below the bone crest. The implant achieved 60 N insertion torque, allowing immediate loading. A universal abutment (Neodent GM 3.3x6x2.5 mm) torqued to 20 N was installed.

Figure 7 – Verification of implant positioning.

A provisional cylinder and a PMMA crown milled from previous digital scanning were used, adjusted out of occlusion to avoid contacts in maximum intercuspation and excursions (Figure 8).

The bone defect was filled with small-granulation xenograft (Cerabone®) and covered with a slow-resorption collagen membrane (Jason®) (Figures 9 and 10).

To enhance soft-tissue stability, de-epithelialized connective tissue graft harvested from the palate was positioned bucally and stabilized with sutures (Figures= 11). Suspensory and simple interrupted sutures were placed to achieve tension-free flap stabilization (Figure 12) At the end of the procedure, blue®m gel was applied to the surgical site (Figure 13).

Postoperative prescriptions included antibiotics (Amoxicillin 500mg - 7 days), anti-inflammatories (Spidufen 600mg - 5 days), and analgesics (Dipyrone 1mg - 5 days). Healing was uneventful with complete fistula resolution and no pain. Follow-ups at 7, 21 and 60 days showed provisional stability, preserved papillae, and maintained vestibular contour (Figures 14, 15 and 16).

After 90 days, definitive metal-free prosthesis was fabricated. At 180 days, excellent soft-tissue maturation and esthetic results were observed (Figure 17).

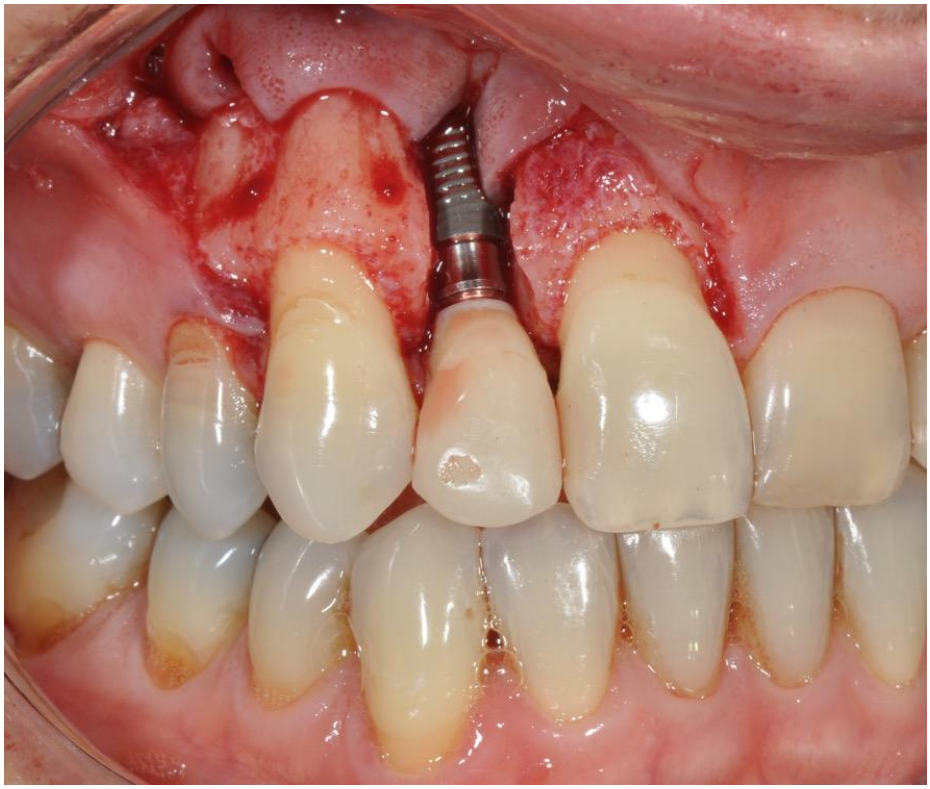

Figure 8 – Implant installed with PMMA milled provisional captured.

Figure 9 – Socket filled with xenograft.

Figure 10 – Collagen membrane adapted.

Figure 11 – Connective tissue graft positioned.

Figure 12 – Suspensory and simple interrupted sutures were placed to achieve tension-free flap stabilization.

Figure 13 –blue®m gel applied immediately postoperative.

Figure 14 – 7-day postoperative follow-up.

Figure 15 – 21-day postoperative follow-up.

Figure 16 – 60-day postoperative follow-up.

Figure 17 – 180-day follow-up after delivery of final prosthesis.

Discussion

Longitudinal root fractures associated with chronic periapical infection represent a challenging clinical scenario, often leading to tooth extraction due to the unfavorable prognosis of conservative approaches[1,2]. In the esthetic zone, immediate implant placement has been widely advocated as a predictable strategy to preserve alveolar bone and soft-tissue architecture, provided that strict surgical and prosthetic criteria are met[3–6].

In the present case, infection control was addressed through a combined systemic and local approach. Systemic antibiotic therapy with amoxicillin (500 mg, three times daily) was initiated 7 days prior to surgery and maintained for 7 days postoperatively, resulting in a total of 14 days of antimicrobial coverage. This extended regimen was selected due to the presence of a fistula, extensive periapical lesion, and longitudinal fracture, conditions that are known to increase bacterial load and risk of postoperative complications[1,2,6]. Although immediate implant placement protocols often recommend shorter antibiotic courses, extended coverage may be justified in infected sites undergoing immediate implantation and regenerative procedures[6,7]. Postoperative inflammation was controlled with a non-steroidal anti-inflammatory drug (ibuprofen 600 mg, every 8 hours for 5 days), following commonly accepted oral surgery protocols.

Primary implant stability is a prerequisite for immediate loading, with insertion torque values above 30–35 N·cm being generally recommended [5–7]. In this case, a torque of 60 N·cm was achieved through palatal positioning and bicortical anchorage, allowing immediate provisionalization. Subcrestal implant placement of approximately 3 mm was chosen, as evidence suggests that subcrestal positioning may reduce marginal bone remodeling and improve long-term peri-implant bone stability when combined with appropriate prosthetic management[8–10,24,25].

The management of the buccal bone defect using a xenogeneic bone substitute (cerabone®) in combination with a collagen membrane (Jason®) is supported by studies demonstrating predictable volumetric stability and favorable regenerative outcomes[26,27,29]. The addition of a connective tissue graft further contributed to soft-tissue thickness and contour stability, which is particularly critical in immediate implant placement in the esthetic zone. Systematic reviews and randomized clinical trials have consistently shown superior esthetic outcomes and soft-tissue stability when connective tissue grafts are associated with immediate implants[14–16].

An important aspect of this case was the transoperative use of an active oxygen gel (blue®m) for socket decontamination. Active oxygen-releasing agents have demonstrated antimicrobial effects against periopathogenic bacteria and favorable biological responses in periodontal and peri-implant tissues[17–21]. In vitro studies have shown that blue®m gel exhibits antimicrobial activity comparable to chlorhexidine while maintaining a favorable biocompatibility profile [17]. Clinical reports have also described its successful use in periodontal therapy, peri-implant diseases, and complex conditions such as medication-related osteonecrosis of the jaws[18–21].

It is important to note that blue®m gel is not classified as a sterile surgical material. However, it is manufactured under controlled conditions and considered microbiologically safe for clinical use when proper handling protocols are followed[17–21]. During transoperative application, the gel should be dispensed using sterile instruments, avoiding direct contact between the container tip and the surgical field. The use of a previously opened container may be acceptable provided that it has been stored according to the manufacturer's recommendations, remains within the expiration date, and has not been contaminated. For surgical applications, dedicating a container exclusively for operative use is advisable to minimize cross-contamination risk, a practice consistent with recommendations for adjunctive non-sterile agents used in oral surgery[17–21].

The integration of systemic antimicrobial therapy, local active oxygen decontamination, immediate implant placement, regenerative procedures, connective tissue grafting, and immediate provisionalization in a single surgical stage aligns with current evidence supporting simplified protocols in the esthetic zone[4,5,10,22–25]. Single-stage approaches reduce the number of surgical interventions, shorten treatment time, and enhance patient comfort while maintaining high success rates and favorable esthetic outcomes.

Despite the inherent limitations of a single case report and the relatively short follow-up period, the present findings are consistent with the available literature and support the use of a carefully planned single-stage protocol for the management of longitudinal root fractures associated with infection in the anterior maxilla.

Conclusion

The single-stage protocol combining active oxygen gel decontamination, immediate implant placement and loading, and simultaneous hard- and soft-tissue grafting proved to be a predictable therapeutic approach for longitudinal root fracture in the esthetic zone, allowing

infection control, primary implant stability, and preservation of peri-implant tissues, while reducing treatment time and surgical morbidity compared with conventional staged protocols.

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RELATO DE CASO

Relato clínico de dois fluxos (digital parcial ou analógico) na reabilitação implantossuportada de mandíbulas

REPORTE DE CASO

Reporte clínico de dos flujos de trabajo (parcialmente digital y analógico) en la rehabilitación implantosoportada de la mandíbula

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Resumo

A reabilitação total mandibular com implantes em carga imediata requer precisão no planejamento e execução cirúrgico-protética. O objetivo deste estudo é fazer o relato de duas abordagens, do planejamento à reabilitação, por meio de fluxo digital parcial ou analógico. No primeiro caso, como os dentes anteriores estavam presentes e a dimensão vertical de oclusão (DVO) era correta, foi realizado um escaneamento intraoral e tomografia computadorizada, e o planejamento cirúrgico foi realizado no software CoDiagnostiX® e o protético no software Exocad®, para confecção de um guia cirúrgico e um guia multifuncional. Foram instalados 4 implantes Helix GM (Neodent®) e após a moldagem, foi instalado uma prótese implantossuportada imediata. No segundo, foi realizado moldagem, ajustes dos planos de cera, montagem em articulador semi ajustável (ASA) e prova dos dentes, sendo confeccionado um guia multifuncional por duplicação. Foram instalados 4 implantes BLX (Straumann®) guiados proteticamente e após a moldagem, instalado uma prótese implantossuportada imediata. Na análise tomográfica os implantes mostraram-se em posição ideal. Ambas as técnicas proporcionaram eficiência em relação a estética e biomecânica da prótese, alcançando um ótimo resultado funcional. O uso do fluxo digital parcial mostrou mais agilidade comparado ao analógico, reduzindo o tempo de tratamento. Com base na experiência coletada na resolução dos dois casos clínicos, parece lícito concluir que os dois tipos de abordagem permitem alcançar bons resultados em casos de reabilitação implantossuportada. No entanto, o fluxo digital parcial reduz o número de sessões de atendimento e aumenta o conforto ao paciente.

Palavras-chave: Carga imediata em implante dentário; Planejamento de prótese dentária; Prótese dentária.

Resumen

La rehabilitación mandibular completa con implantes de carga inmediata requiere precisión en la planificación y ejecución quirúrgica y protésica. El objetivo de este estudio es informar dos enfoques, desde la planificación hasta la rehabilitación, utilizando un flujo de trabajo parcialmente digital o analógico. En el primer caso, dado que los dientes anteriores estaban presentes y la dimensión vertical de oclusión (DVO) era correcta, se realizó un escaneo intraoral y una tomografía computarizada, y la planificación quirúrgica se llevó a cabo utilizando el software CoDiagnostiX® y la planificación protésica utilizando el software Exocad®, para la fabricación de una guía quirúrgica y una guía multifuncional. Se colocaron cuatro implantes Helix GM (Neodent®), y después de la toma de impresión, se colocó una prótesis inmediata soportada por implantes. En el segundo caso, se realizó la toma de impresión, ajustes del plano de cera, montaje en un articulador semiajustable (ASA) y prueba de dientes, y se fabricó una guía multifuncional por duplicación. Se colocaron cuatro implantes BLX (Straumann®) mediante guía protésica y, tras la toma de impresiones, se instaló una prótesis inmediata sobre implantes. El análisis tomográfico mostró que los implantes se encontraban en una posición ideal. Ambas técnicas demostraron eficiencia en términos de estética y biomecánica de la prótesis, logrando un excelente resultado funcional. El uso del flujo de trabajo digital parcial mostró mayor rapidez en comparación con el enfoque analógico, reduciendo el tiempo de tratamiento. Con base en la experiencia adquirida en la resolución de los dos casos clínicos, parece razonable concluir que ambos enfoques permiten obtener buenos resultados en casos de rehabilitación con implantes. Sin embargo, el flujo de trabajo digital parcial reduce el número de sesiones de tratamiento y aumenta la comodidad del paciente.

Palabras clave: Carga inmediata en implantes dentales; Planificación de prótesis dentales; Prótesis dentales

Introdução

A reabilitação oral em pacientes edêntulos com implantes dentais em carga imediata tem revolucionado a prática odontológica ao combinar previsibilidade funcional com alta satisfação dos pacientes[1–4]. No contexto das exodontias múltiplas no arco mandibular, a instalação de implantes para suportar próteses híbridas do tipo protocolo apresenta desafios técnicos que exigem alta precisão no planejamento e na execução cirúrgico-protética. Para superar esses desafios, recomenda-se o planejamento protético prévio, que possibilita a confecção de um guia multifuncional contendo todas as informações necessárias para alcançar uma reabilitação correta e previsível. A técnica é descrita na literatura com índice de sucesso de 100% para implantes e próteses[4–7].

Com o desenvolvimento dos escâneres intra-orais (EIO) a forma de conduzir os casos proteticamente tem sido modificada. A possibilidade de eliminar ou reduzir o uso de moldagens, assim como de diminuir o número de sessões clínicas sem comprometer a qualidade final do trabalho, tem sido frequentemente mencionada[8,9].

Assim, técnicas precisam ser desenvolvidas para abordagens digitais sob o ponto de vista protético. Em relação ao aspecto cirúrgico esses benefícios estão atrelados à possiblidade de planejamento virtual detalhado, que permite mapear com precisão a anatomia do paciente utilizando dados obtidos por tomografias computadorizadas e escaneamentos intraorais[10].

Estudos apontam a superioridade do fluxo digital nos aspectos cirúrgicos e protéticos[10–13].

Diante desse contexto, o presente relato de casos tem como objetivo descrever dois casos clínicos com características iniciais semelhantes, utilizando o fluxo digital parcial em um deles e o fluxo analógico no outro, para discutir as diferentes possibilidades de abordagem.

Caso clínico 1

Paciente do sexo feminino, 71 anos, compareceu a clínica da faculdade ILAPEO (Curitiba, PR) para reabilitação com implantes dentais na arcada dentária inferior. Relatou durante anamnese a presença de doenças sistêmicas controladas, diabetes mellitus tipo 2 e hipertensão arterial. Já havia realizado uma reabilitação total implantossuportada da arcada superior anteriormente na mesma faculdade.

Durante exame clínico inicial, foi possível verificar ausência dos elementos 35, 36, 37, 38, 47 e 48, e implantes dentais na região dos dentes 31, 45 e 46, e quatro implantes na arcada superior reabilitados por uma prótese híbrida dentogengival (Figura 1 - A, B). No exame radiográfico, constatou-se uma perda óssea ao redor do implante da região do dente 45, e falta de quantidade óssea em altura para nova reabilitação com implante na mesma região, assim como falta de altura na região de 35 e 36 para instalação de implantes convencionais (Figura 1- C).

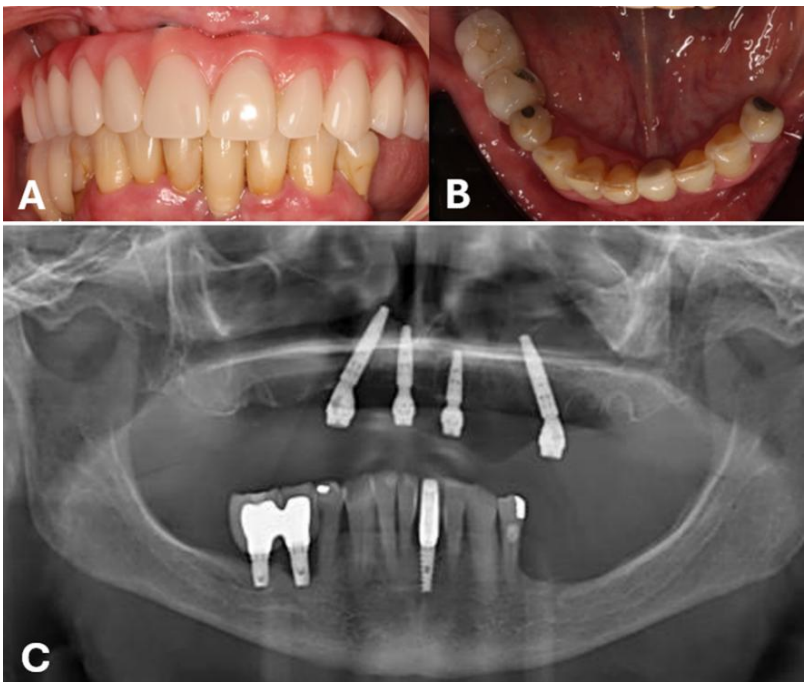

Figura 1 – **A** - Aspecto inicial intraoral frontal em oclusão; **B-** Aspecto inicial intraoral da arcada inferior; **C** – Radiografia panorâmica inicial.

A paciente recebeu duas opções de tratamento. A primeira com explantação dos implantes 45, 46, cirurgias para lateralização dos feixes vasculonervosos e instalação de implantes nesses setores posteriores. A segunda opção previa a remoção dos dentes e implantes presentes no arco inferior, regularização óssea e instalação de 4 implantes retentores de prótese fixa mandibular de arco total do tipo híbrida. Ela escolheu a segunda opção.

O preparo protético prévio foi realizado utilizando fluxo digital. Inicialmente, foi realizado um escaneamento intraoral utilizando o escâner Virtuo Vivo™ (Straumann®, Basel, Suíça). Para melhorar a identificação dos tecidos moles durante o escaneamento, foi utilizado um artefato confeccionado com resina TopDam e adesivo OralAid (Figura 2 A-B). Esse processo resultou na criação de um modelo tridimensional no formato STL (Standard Tessellation Language ou Standard Triangle Language).

Adicionalmente, foi obtida uma tomografia computadorizada de feixe cônico (CBCT), que forneceu um conjunto de arquivos DICOM (Digital Imaging and Communications in Medicine). A integração desses dados permitiu a sobreposição precisa entre o modelo tridimensional e as imagens tomográficas. O software de planejamento digital Exocad® (Exocad GmbH, Frankfurt, Alemanha) foi utilizado para a montagem digital dos dentes. O planejamento tridimensional de instalação virtual dos implantes foi realizado com o software CoDiagnostiX® (Dental Wings GmbH, Chemnitz, Alemanha), permitindo a análise detalhada da anatomia mandibular e a definição da posição ideal dos implantes, relacionando à posição dos dentes montados. Após aprovação dos implantes, foi gerado o CAD do guia cirúrgico personalizado e confeccionado por impressão (Figura 2-C). O guia multifuncional foi obtido por impressão da montagem virtual dos dentes. (Figuras 2-D e E).

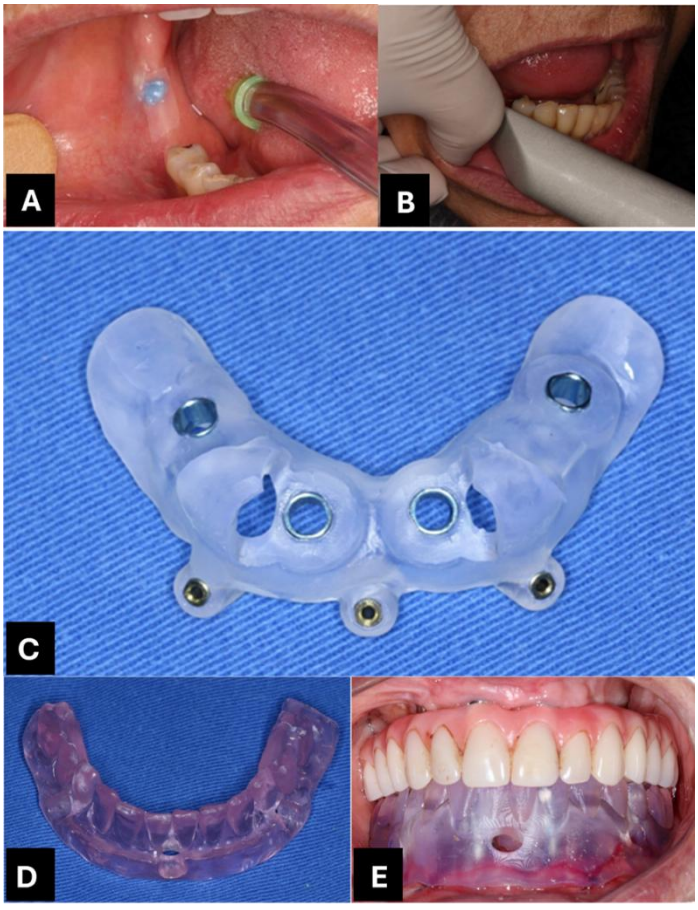

Figura 2 **-** Planejamento e confecção do guia cirúrgico e multifuncional**: A-** Preparo para escaneamento intraoral mandibular com TopDam® e OralAid®; **B**- Escaneamento com escâner Virtuo Vivo™ (Straumann®, Basel, Suíça); **C-** Guia cirúrgico impresso com as anilhas em posição. **D-** Guia Multifuncional impresso a partir do enceramento virtual;
E- Guia Multifuncional posicionado em boca, após as exodontias e remoção dos implantes.

Como medicação pré-operatória, foram administrados 4 mg de Dexametasona e 5 mg de Diazepam. Após a aplicação de anestesia por bloqueio regional bilateral dos nervos alveolar inferior, bucal, lingual e mentual com Mepivacaína 2% com epinefrina 1:200.000 (Mepiadre®, DFL, Rio de Janeiro, Brasil), a paciente foi submetida à uma pequena incisão e descolamento mucogengival somente para a realização das exodontias dos dentes remanescentes e remoção de implantes na região dos elementos 45 e 31. Os dentes 33 e 43 foram mantidos, funcionando como apoio para estabilização do guia virtual cirúrgico, sendo posteriormente extraídos após a instalação dos implantes. Os implantes Helix GM Acqua (Neodent®, Curitiba, Brasil) de 3,75 x 13 mm foram inseridos nas regiões dos dentes 34 e 44, enquanto implantes de 3,5 x 13 mm foram posicionados nas regiões dos dentes 32 e 42. Todos apresentaram torque progressivo de pelo menos 40 Ncm. A instrumentação e instalação dos implantes foi realizada com o auxílio do sistema de cirurgia guiada EasyGuide (Neodent®, Curitiba, Brasil) (Figura 3) apresentaram torque na guia, os torques dos implantes foram conferidos e foram instalados mini- pilares cônicos retos (Neodent®, Curitiba, Brasil) de 3,5mm de altura nos implantes da região 34, 32, 42 e um minipilar cônico angulado de 17 graus de 3,5 mm (Neodent®, Curitiba, Brasil) na região do dente 44. (Figura 3 B) A sutura foi realizada com fio mononylon soft blue 5-0 (Techsuture, Bauru, SP) com pontos simples interrompidos e em colchoeiro horizontal e vertical. O tempo cirúrgico total, desde a anestesia até a instalação dos minipilares, foi de aproximadamente 150 minutos. O tratamento completo foi finalizado em 3 sessões clínicas (Planejamento/Escaneamento, Cirurgia/Moldagem e Instalação da Prótese após 48h)

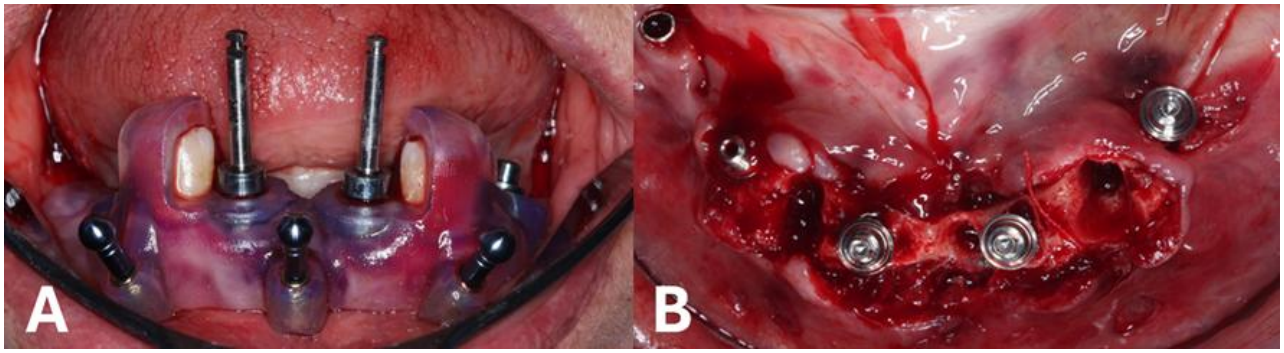

Figura 3 - Procedimento cirúrgico: A- Guia virtual cirúrgico posicionado e estabilizado com pinos de fixação para instrumentação e instalação dos implantes; B- Aspecto oclusal dos minipilares cônicos instalados sobre os implantes.

Foram instalados transferentes quadrados de moldagem sobre os minipilares, com parafusos protéticos curtos, e estes foram unidos entre si e ao guia com resina tipo Pattern (GC America INC, EUA), três pontos da mesma resina foram colocados na superfície oclusal do guia para registro das relações intermaxilares. (Figura 4-B). Silicone de moldagem Variotime® Medium Flow (Kulzer GmbH, Hanau, Alemanha) foi levada na base do guia para moldagem do rebordo. No pós-operatório foi prescrito Amoxicilina (875mg por 7 dias) e Spidufen (600 mg por 4 dias), e a paciente orientada sobre os cuidados necessários.

A partir do molde com o guia multifuncional, confeccionou-se o modelo de trabalho, no qual a prótese foi projetada e finalizada. Após 24 horas foi realizada a prova funcional dos dentes, e com 48 horas foi realizada a instalação da prótese implantossuportada mandibular, atendendo aos critérios estéticos e funcionais (Figura 4 - A e B). Após 10 dias as suturas foram removidas e realizado uma radiografia panorâmica de controle, o tecido mole apresentou-se saudável e a paciente relatou satisfação total tanto com o procedimento cirúrgico quanto protético. (Figura 4- C e D)

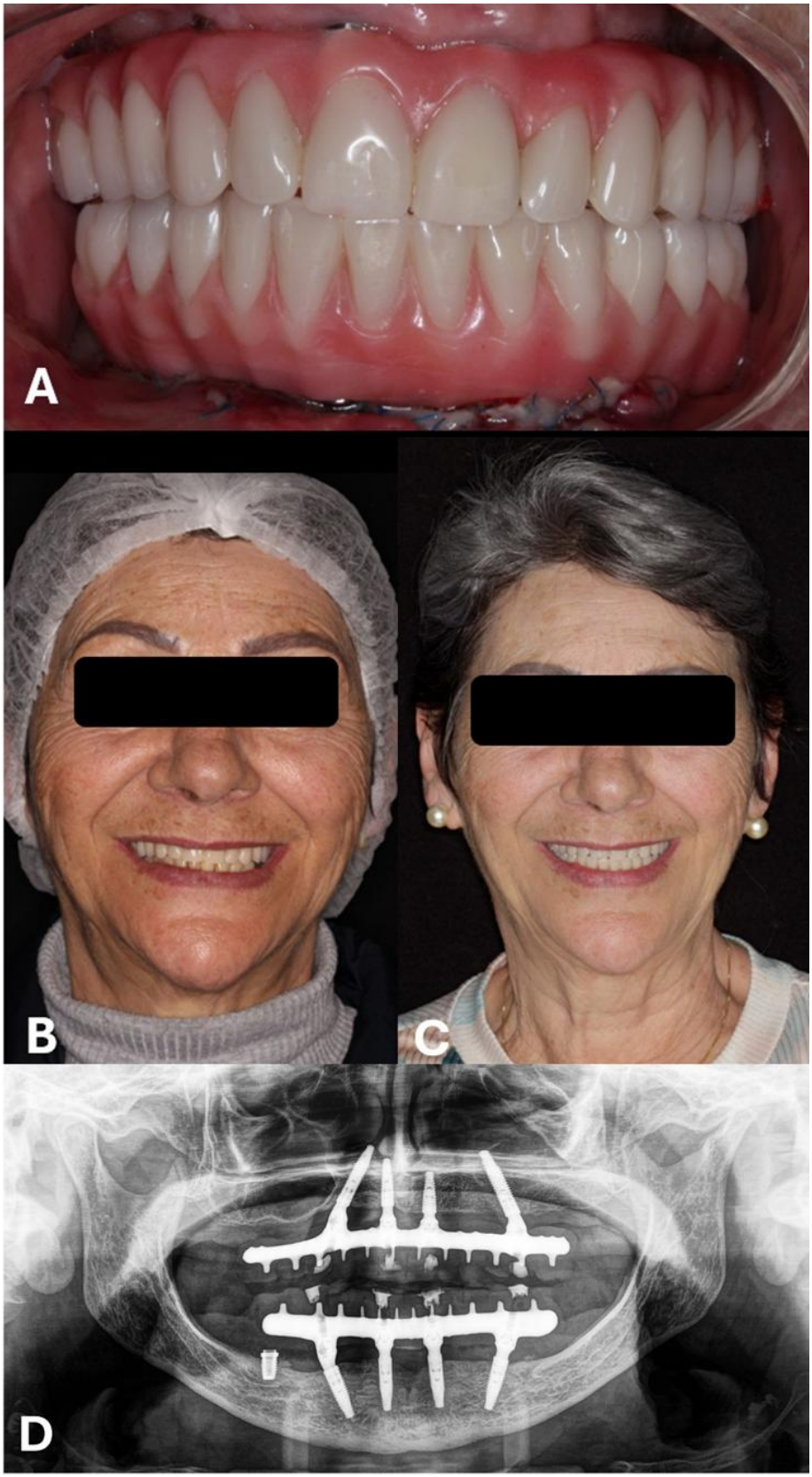

Figura 4- A- Aspecto frontal intraoral da reabilitação tipo híbrida dento gengival (protocolo) mandibular instalada em carga imediata através de fluxo digital parcial; B- Aspecto frontal extraoral inicial; C- Aspecto frontal extraoral no pós-operatório após a instalação da prótese implantossuportada. D- Radiografia Panorâmica após 10 dias de pós-operatório.

Caso clínico 2

Paciente do sexo feminino, 82 anos, procurou atendimento odontológico na faculdade ILAPEO, relatando mobilidade severa dos dentes inferiores e dificuldade para mastigação. Durante a anamnese relatou osteoporose e insuficiência renal crônica leve, ambas sob acompanhamento médico regular e controladas, não apresentando contraindicações para o tratamento planejado. A paciente relatou ausência de elementos dentais na arcada inferior e dificuldade em ter reabilitações protéticas eficazes ao longo dos anos.

No exame clínico inicial apresentou condição periodontal Estágio IV 14, com mobilidade e inflamação gengival nos dentes remanescentes mandibulares, associado à reabsorção óssea significativa na região posterior (Figura 5 – B). Exames radiográficos complementares confirmaram uma atrofia óssea moderada a severa nos setores posteriores e condições estruturais satisfatórias na região interforaminal para instalação de implantes. (Figura 5 – C). Além disso, a paciente apresentava uma prótese total superior com problemas na adaptação, que foi identificada como fator adicional para sua queixa funcional e estética.

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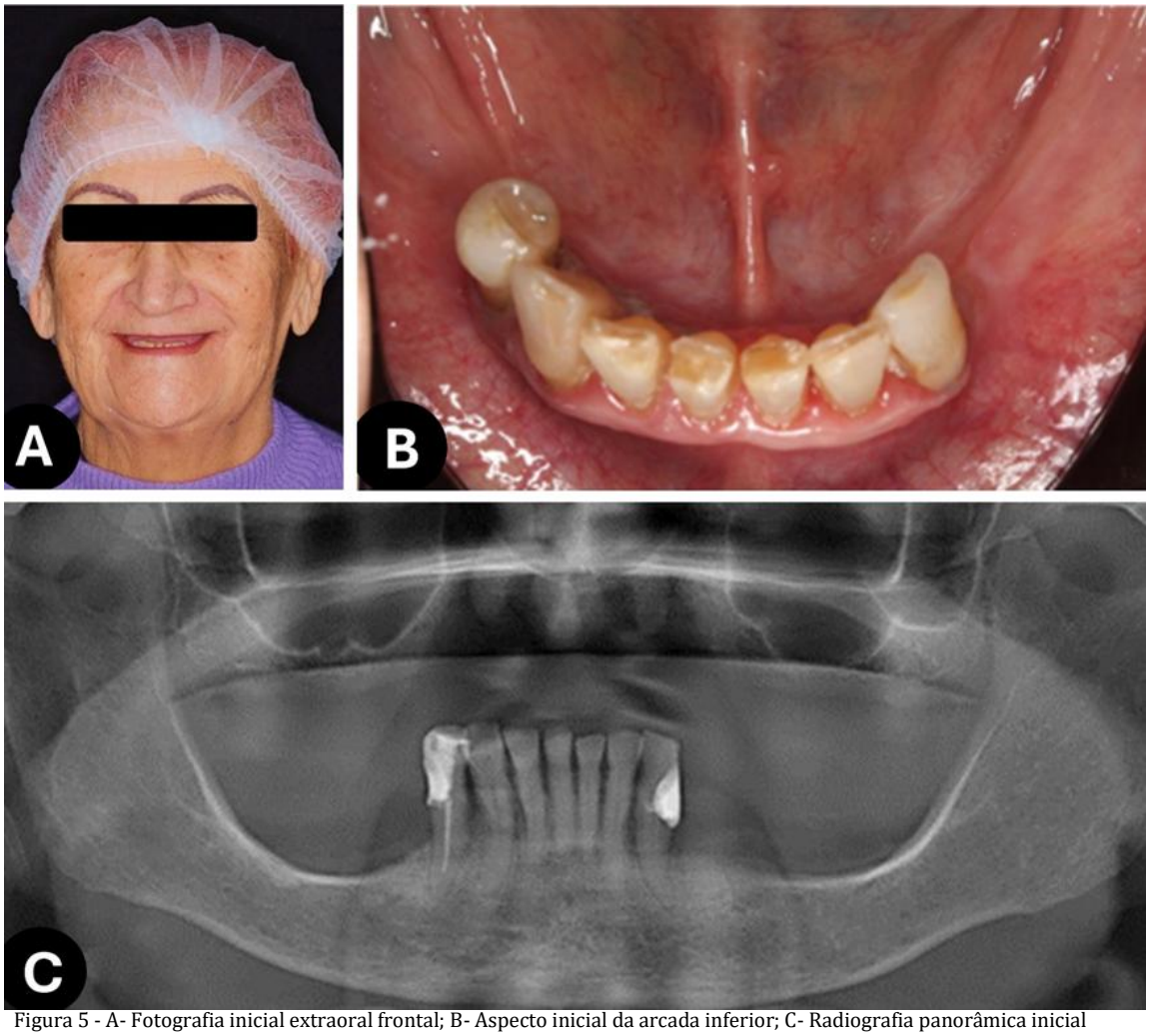

Figura 5 - A- Fotografia inicial extraoral frontal; B- Aspecto inicial da arcada inferior; C- Radiografia panorâmica inicial mostrando a reabsorção óssea mandibular.

O plano de tratamento incluiu a confecção de uma nova prótese total superior para reabilitação da arcada superior, exodontias dos elementos dentais remanescentes inferiores (elementos 33, 32, 31, 41, 42, 43 e 44), e instalação de uma prótese fixa híbrida dentogengival inferior (protocolo) sobre quatro implantes interforaminais, proporcionando uma reabilitação em carga imediata. Foi realizado o planejamento protético prévio utilizando o fluxo analógico, considerando as limitações ósseas e a idade da paciente.

O preparo protético prévio incluiu moldagem anatômica dos dois arcos, moldagem funcional da maxila, ajuste dos planos de cera, registro (Figura 6- A e B) e montagem em ASA, e prova da montagem dos dentes. Á partir da montagem foi feito a duplicação e confecção do guia multifuncional.

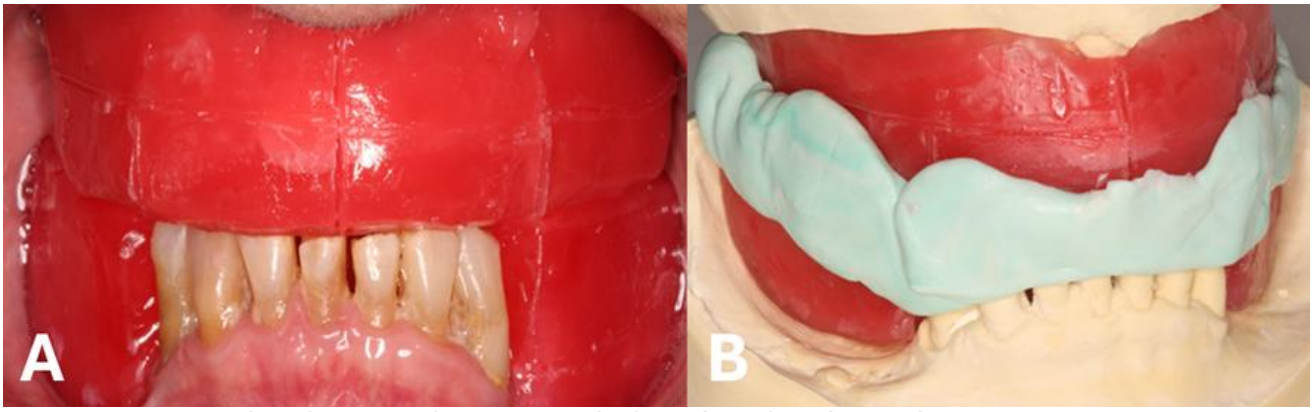

Figura 6 - A- Planos de cera ajustados; B- Registro oclusal com silicone de condensação denso para montagem em ASA.

O procedimento cirúrgico foi realizado com anestesia local, os dentes inferiores remanescentes (elementos 33, 32, 31, 41, 42, 43 e 44) foram extraídos, seguidos da regularização do rebordo alveolar (Figura 7 A-D) para adequação do espaço protético.

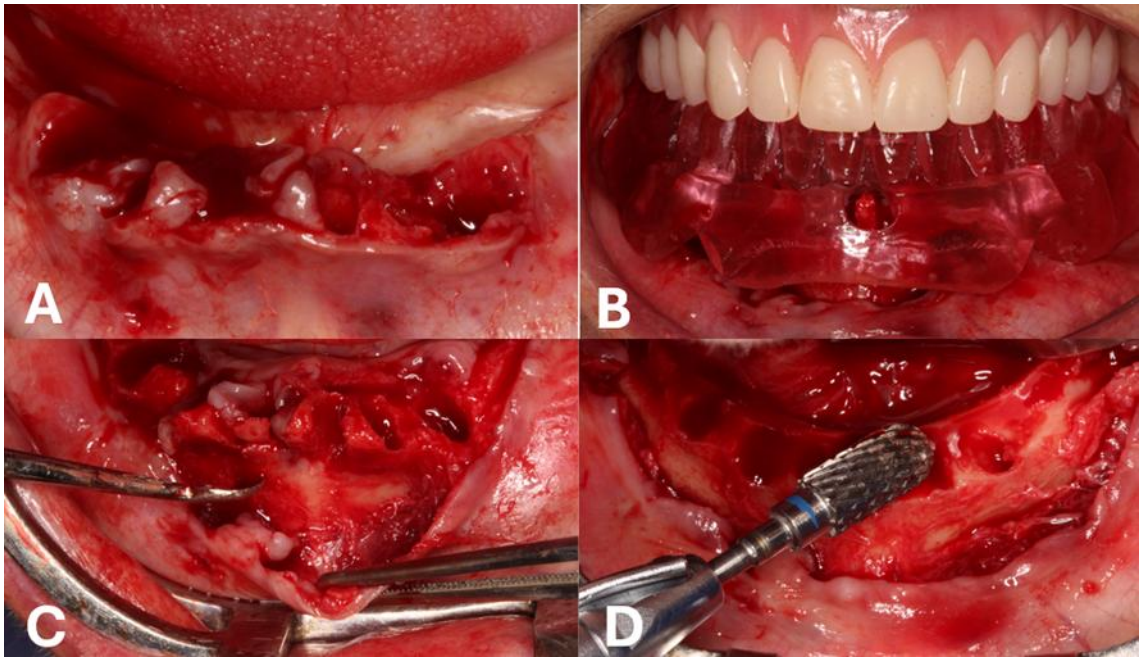

Figura 7 - Procedimento cirúrgico: A- Alvéolos pós exodontia dos elementos dentais remanescentes; B- Prova do guia multifuncional pós exodontias; C- Demarcação da altura da osteotomia; D- Osteotomia do processo alveolar mandibular.

Com o uso do guia multifuncional foram instalados quatro implantes BLX (Straumann ®, Institut Straumann AG, Basel, Suíça), com superfície SLActive, na região interforaminal (32 e 42- 4,0x12 mm), (34 e 44- 4,5x12 mm).

Todos os implantes apresentaram torque de inserção, superior a 40 Ncm (Figura 9-A). Em seguida, foram instalados os pilares aparafusados retos (SRA, Straumann®) com 3,5 mm de altura de transmucoso. (Figura 8-B).

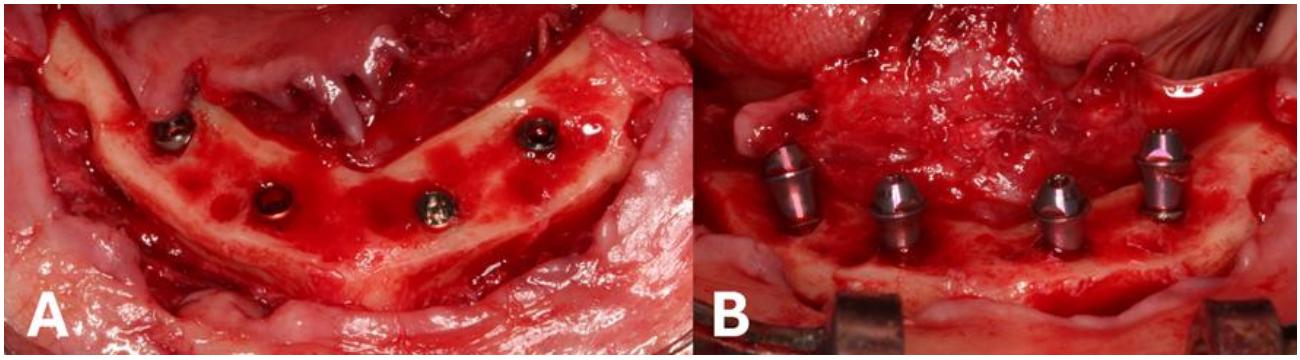

Figura 8 - **A**- Implantes BLX (Straumann®) instalados; **B**- Pilares SRA instalados.

As suturas foram realizadas com fio mononylon blue 4-0 (Techsuture ®, Bauru, SP, Brasil) (Figura 9). Devido às etapas manuais de moldagem e ajustes, o tempo cirúrgico foi superior ao Caso 1, totalizando cerca de 180 minutos.

Foram necessárias 5 sessões clínicas (Moldagem inicial, Planos de cera/Registro, Prova dos dentes, Cirurgia/Moldagem e Instalação da Prótese), além de uma sessão extra para refinamento do registro oclusal devido a interferências observadas na prova.

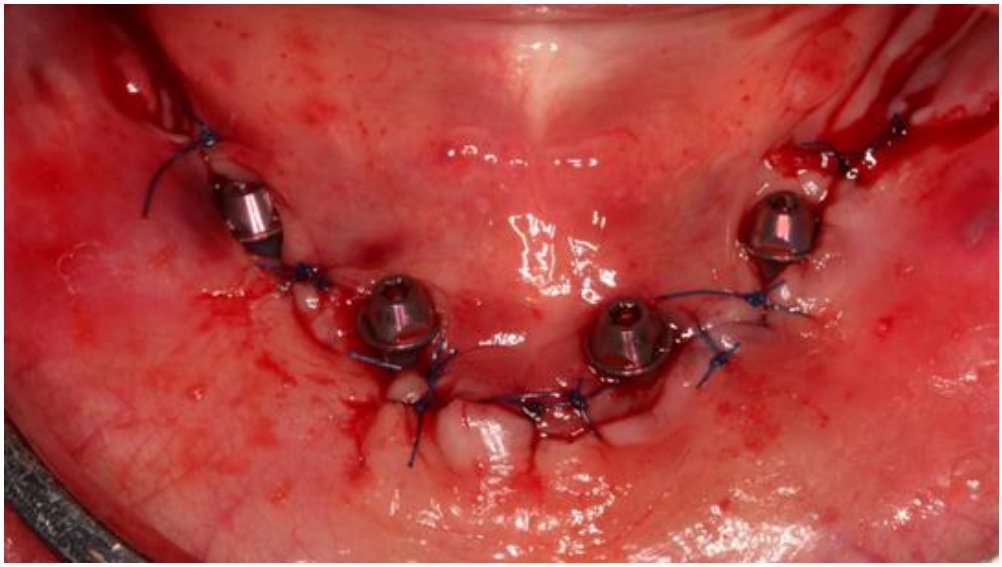

Figura 9 - Aspecto tecidual após a sutura

O guia multifuncional foi posicionado em boca e unido aos transferentes de moldeira aberta (Straumann AG®, Basel, Suíça) e a guia com resina tipo Pattern (GC America INC, EUA), para moldagem com silicona de adição Variotime® Medium Flow (Kulzer GmbH, Hanau, Alemanha) (Figura 10- A e B). Foram realizados três pontos com a mesma resina na região oclusal para registro.

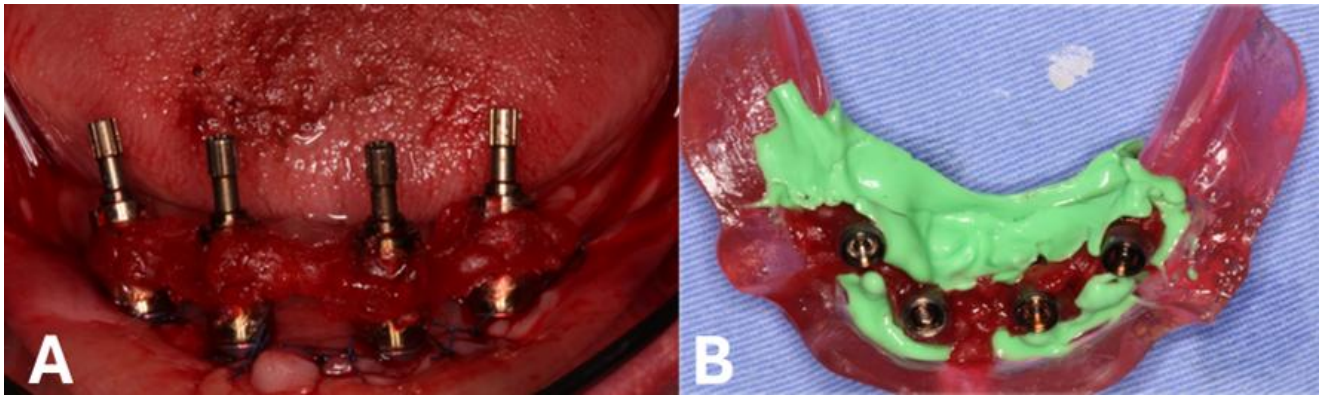

Figura 10 - **A**- União dos transferentes com resina tipo Pattern; **B**- Molde com guia multifuncional

Após 24 horas foi realizada a prova dos dentes. Foi necessário um refinamento no registro oclusal com resina tipo Pattern (GC America INC, EUA) (Figura 11), devido a uma interferência oclusal na região posterior esquerda.

As próteses foram instaladas após 48 horas e uma radiografia panorâmica foi realizado para controle futuro (Figuras 12 A-B).

Figura 11 - Novo registro oclusal durante a prova dos dentes

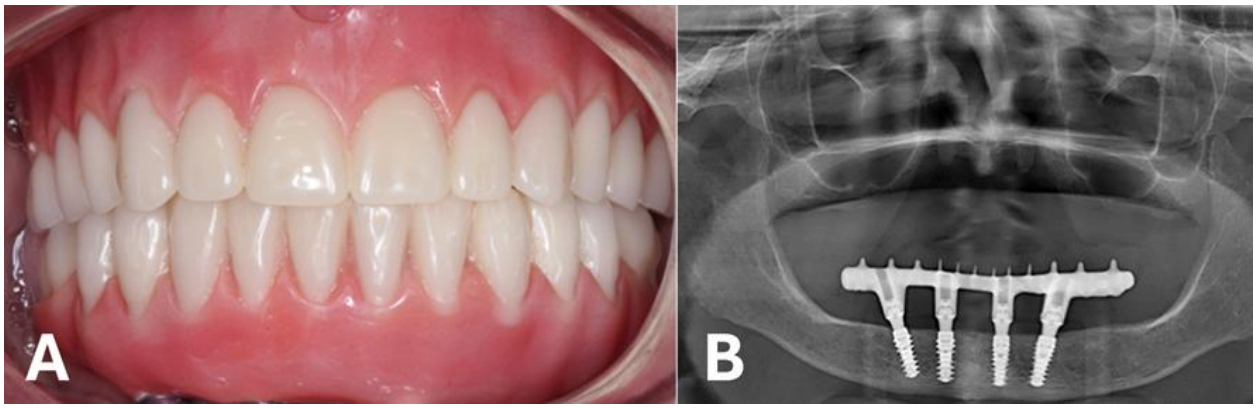

Figura 12 **- A-** Aspecto frontal em oclusão das próteses após instalação; B- Radiografia panorâmica pós-operatória imediata.

Após 10 dias, foi realizado a remoção das suturas, a paciente relatou grande satisfação com a reabilitação, destacando melhorias significativas em sua mastigação, fala e aparência. (Figura 13 A e B).

Figura 13 - A- Aspecto facial frontal inicial; B- Aspecto facial frontal final

Discussão

A análise comparativa dos dois casos clínicos apresentados permite discutir a aplicação prática e os resultados obtidos a partir de diferentes fluxos de trabalho em reabilitações implantossuportadas — o digital parcial e o analógico. Essa comparação é relevante diante das transformações recentes na implantodontia, impulsionadas pela incorporação de tecnologias digitais que têm modificado de forma significativa o planejamento e a execução dos tratamentos. A avaliação das vantagens, limitações e resultados clínicos de cada abordagem possibilita compreender não apenas o impacto da digitalização na previsibilidade e eficiência dos procedimentos, mas também a permanência e importância do método analógico em diferentes contextos clínicos. A seguir, são discutidos os principais aspectos técnicos e clínicos observados em cada fluxo, com base na literatura científica e na experiência obtida durante a condução dos casos.

A integração dessas tecnologias aumenta a previsibilidade dos resultados clínicos, permitindo o ajuste individualizado do posicionamento cirúrgico dos implantes e do planejamento protético, o que otimiza a relação entre funcionalidade e estética. Além disso, a observação dos dois tipos de fluxo permitiu comprovar que a associação de parte digital permitiu potencializar a eficiência ao reduzir o tempo clínico e laboratorial e diminuir as incertezas associadas ao processo tradicional, corroborando com informações colocadas em estudo[12]. Permitiu também observar que tecnologias como guias cirúrgicos fabricados por manufatura aditiva (impressão 3D) e softwares avançados de planejamento têm desempenhado papel crescente no sucesso dessa abordagem, garantindo maior precisão e segurança — especialmente em casos de carga imediata, como tem sido considerado[13].

Em contrapartida, o fluxo analógico, que vem sendo usado com sucesso há alguns anos [4–7] foi aqui utilizado e mostrou manter sua relevância como estratégia robusta e amplamente difundida, capaz de atender às necessidades de diferentes realidades clínicas, sobretudo onde recursos tecnológicos ainda não são acessíveis. Essa abordagem depende menos de recursos digitais e baseia-se, em grande medida, na experiência clínica do profissional, que se torna fator determinante para alcançar alta precisão. A confiabilidade do método analógico reside em sua adaptabilidade, permitindo decisões e ajustes intraoperatórios baseados na observação direta das condições anatômicas e funcionais. Suas principais vantagens incluem maior acessibilidade econômica — particularmente para clínicas em regiões com infraestrutura tecnológica limitada — e flexibilidade para adaptação em casos complexos, nos quais improvisação e ajustes são muitas vezes necessários[15].

Dessa forma, observando as duas abordagens (digital parcial e analógica) é possível perceber que atuam de maneira complementar na odontologia contemporânea, respondendo a diferentes demandas clínicas, contextos socioeconômicos e preferências profissionais, o que reafirma sua relevância em cenários que exigem precisão, previsibilidade e satisfação dos pacientes, confirmando informações prévias[16].

A estratégia protética de preparo prévio por fluxo digital parcial, utilizada no primeiro caso clínico, tem se mostrado eficiente para o planejamento e execução de procedimentos complexos em implantodontia. Estudos [16–19] indicam que a integração de softwares digitais — como CoDiagnostiX® e Exocad® (utilizados neste caso) — com escaneamentos intraorais e tomografias computadorizadas possibilita um planejamento cirúrgico e protético mais preciso e confiável. Foi possível confirmar que as principais vantagens dessa abordagem estão na previsibilidade do tratamento: o planejamento virtual detalha cada etapa do procedimento, auxilia na antecipação de potenciais complicações e contribui para a otimização dos resultados estéticos e funcionais.

A redução do tempo clínico e laboratorial é outro benefício associado ao uso de ferramentas digitais, que aceleram tanto o planejamento quanto a confecção de próteses imediatas, promovendo uma abordagem mais ágil e integrada[17,20]. Esse efeito foi observado no caso clínico 1: a comparação do número de sessões mostrou redução do tempo total de tratamento, incluindo menor tempo de cadeira durante o ato cirúrgico. Além disso, a precisão na instalação dos implantes, quando se empregam guias cirúrgicos impressos em 3D, assegura a posição planejada dos implantes — evidenciada por análises tomográficas subsequentes —, conforme também verificado no presente relato[21–23].

Entretanto, o fluxo digital parcial apresenta limitações que devem ser consideradas. O investimento inicial pode ser elevado devido aos custos de equipamentos, softwares e treinamento, o que constitui barreira para clínicas de menor porte[12]. Outro desafio é a curva de aprendizado inerente às novas tecnologias, que requer tempo e dedicação para atingir competência técnica adequada. Ademais, a dependência tecnológica torna o processo vulnerável a falhas de hardware ou software, o que pode atrasar ou complicar a execução dos procedimentos[12,24,25].

Assim, o fluxo analógico continua amplamente utilizado em implantodontia, especialmente em contextos com recursos tecnológicos limitados — fato confirmado no relato do caso clínico 2. Nesse caso foram

necessárias mais sessões clínicas e o tempo cirúrgico foi maior, mas o resultado foi igualmente satisfatório. O protocolo analógico incluiu moldagens, ajustes em cera e montagem em ASA, procedimentos que permanecem fundamentais em muitas práticas. Sua principal vantagem é a acessibilidade, uma vez que não exige equipamentos ou softwares avançados, tornando-o viável em numerosas clínicas. Outra vantagem relevante é a adaptabilidade: por se tratar de um método baseado na observação direta, permite ajustes imediatos durante o procedimento, conferindo maior controle manual ao clínico. Essa flexibilidade é particularmente valiosa em cenários clínicos complexos, nos quais condições anatômicas desafiadoras demandam soluções personalizadas[26].

Apesar desses pontos fortes, o fluxo analógico apresenta desvantagens quando comparado ao digital. Tendencialmente, é mais demorado tanto em termos de tempo clínico quanto de tempo laboratorial, o que pode reduzir a produtividade do consultório e prolongar o tratamento. A previsibilidade estética e funcional também pode ser inferior à oferecida por métodos digitais, os quais permitem simulações virtuais detalhadas. Adicionalmente, o fluxo analógico pode ser mais fatigante para o paciente, em razão do maior número de consultas e da natureza manual de várias etapas, que por vezes exigem repetições [11–13].

A avaliação da percepção de conforto e aceitabilidade foi realizada por meio de entrevistas qualitativas pós-operatórias, nas quais as pacientes foram questionadas sobre o nível de incômodo durante os procedimentos de moldagem / escaneamento e o tempo de permanência em cadeira.

A técnica do Caso 1 (digital parcial) mostrou-se superior em aceitabilidade principalmente pela substituição das moldagens convencionais pelo escaneamento intraoral. A literatura indica que o uso de escâneres reduz o reflexo de vômito e a ansiedade do paciente em comparação aos materiais de moldagem tradicionais usados no Caso 2, que podem ser mais fatigantes devido à natureza manual e necessidade de repetições.

Nos casos descritos, ambas as técnicas demonstraram eficácia, alcançando resultados estéticos e funcionais satisfatórios. A escolha entre uma e outra dependerá de fatores como as condições anatômicas do paciente, a experiência do profissional, os recursos tecnológicos disponíveis e as expectativas do paciente. O fluxo digital parcial destaca-se por sua eficiência e previsibilidade, sendo particularmente útil quando o tempo é fator crítico; já o fluxo analógico permanece como alternativa robusta e flexível em contextos sem acesso pleno à tecnologia digital.

Importa salientar que, nos dois casos apresentados, o guia multifuncional desempenhou papel crucial na transferência do posicionamento dos implantes para o laboratório, confirmando relatos anteriores[1,4-7]. Essa estratégia permite reproduzir com precisão a relação entre implantes e prótese planejada, otimizando a integração entre as etapas cirúrgica e protética e aumentando a previsibilidade e a eficiência do tratamento reabilitador. Por fim, o desenvolvimento e a integração contínua do fluxo digital na fase laboratorial constituem uma área promissora para o aprimoramento das técnicas protéticas e uma busca permanente na prática clínica.

Conclusão

Frente à experiência coletada na condução desses dois casos clínicos, parece lícito concluir que: a reabilitação de casos mandibulares complexos pode ser realizada com sucesso utilizando tanto o fluxo digital parcial quanto o analógico, alcançando resultados funcionais e estéticos satisfatórios. Entretanto, o uso da abordagem digital parcial demonstrou maior agilidade no processo, proporcionando ao paciente uma experiência mais confortável e otimizando a eficiência do tratamento na prática clínica

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JOIS

RELATO DE CASO

Correção de hiperplasia inflamatória crônica associada a técnica do enxerto gengival livre fixado com parafusos gengivais: relato de caso clínico

CASE REPORT

Correction of chronic inflammatory hyperplasia associated with the free gingival graft technique fixed with gingival screws: a clinical case report

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Resumo

A hiperplasia inflamatória crônica é uma condição patológica frequentemente associada ao uso prolongado de próteses mal adaptadas, podendo causar deformidades muco gengivais e comprometimento funcional da mucosa oral. O presente relato de caso tem como objetivo descrever a remoção cirúrgica de uma lesão hiperplásica na região anterior da maxila, associada ao enxerto gengival livre (EGL) fixado com parafusos gengivais. Paciente do sexo feminino, 78 anos, foi submetida à excisão da lesão, seguida da adaptação de EGL removido do palato com fixação por seis parafusos gengivais de titânio, visando promover a imobilidade tecidual e otimizar a cicatrização. No controle de 30 dias, observou-se excelente integração do enxerto, formação de faixa de mucosa queratinizada e estabilidade tecidual sem necessidade de remoção dos parafusos. Os achados deste caso com acompanhamento de 14 semanas sugerem que a fixação do EGL com parafusos pode ser uma alternativa eficaz à sutura convencional, oferecendo maior previsibilidade e conforto no pós-operatório.

Palavras-chave: Fenótipo; Enxerto; Autógeno; Hiperplasia gengival.

Abstract

Chronic inflammatory hyperplasia is a pathological condition frequently associated with the prolonged use of ill-fitting prostheses, potentially causing mucogingival deformities and functional impairment of the oral mucosa. The present case report aims to describe the surgical removal of a hyperplastic lesion in the anterior maxillary region associated with a free gingival graft (FGG) stabilized using gingival screws. A 78-year-old female patient underwent surgical excision of the lesion, followed by adaptation of an FGG harvested from the palate and fixed with six titanium gingival screws in order to promote tissue immobilization and optimize wound healing. At the 30-day follow-up, excellent graft integration, formation of a band of keratinized mucosa, and tissue stability were observed, with no need for screw removal. The findings of this 14-week follow-up case suggest that free gingival graft fixation with screws may be an effective alternative to conventional suturing, providing greater predictability and postoperative comfort.

Keywords: Phenotype; Transplants; Autologous; Gingival hyperplasia.

Introdução

A utilização de enxertos de tecido mole autógenos, como o Enxerto Gengival Livre (EGL), é considerada o padrão-ouro para procedimentos de reconstrução plástica periodontal e peri-implantar devido à sua biocompatibilidade e previsibilidade de resultados[1]. O EGL é uma técnica amplamente utilizada na periodontia para o aumento da gengiva e mucosa queratinizada ao redor de dentes e implantes, além da cobertura radicular em determinados casos[1,2].

A imobilidade do enxerto nos estágios iniciais da cicatrização é um fator determinante para o sucesso do procedimento[3]. Tradicionalmente, o enxerto gengival livre (EGL) é fixado com suturas, contudo a literatura mostra propostas para aprimorar sua estabilidade e favorecer a cicatrização tecidual[4]. Entre essas estratégias, a fixação com parafusos tem se destacado por proporcionar maior estabilidade do enxerto e otimizar sua adesão ao leito receptor[4]. Além disso, diferentes técnicas de EGL, como a utilização de malha expandida revelou vantagens na preservação da largura da mucosa queratinizada e na minimização da contração do enxerto, o que pode contribuir para melhores resultados clínicos a longo prazo[2].

A estabilidade tridimensional da mucosa durante a cicatrização desempenha um papel essencial na previsibilidade e longevidade dos enxertos gengivais livres[3]. A imobilização e a estabilidade do enxerto são condições essenciais para sua revascularização e integração ao leito receptor[5].

Nesse cenário, a fixação do EGL com parafusos tem sido explorada como uma alternativa viável para minimizar a mobilidade do enxerto, promovendo uma cicatrização mais estável e otimizando os desfechos clínicos[4]. Além dos benefícios relacionados à estabilidade inicial do enxerto, a sua imobilização pode contribuir para um melhor conforto pós-operatório do paciente, reduzindo a tração sobre os tecidos adjacentes e minimizando a dor no local restrito da cirurgia[6,7].

Diante desse contexto, este artigo tem como objetivo relatar um caso clínico de EGL fixado com parafusos gengivais para corrigir uma deformidade muco gengival de hiperplasia inflamatória crônica.

Relato de Caso

Paciente com 78 anos, sexo feminino, raça branca, procurou a Faculdade Ilapeo para tratamento de reabilitação oral. Foi realizada anamnese, exame clínico inicial, exames radiográficos e exames laboratoriais complementares. Ao exame inicial, identificou-se uma lesão de Hipertrofia Inflamatória Crônica (HIC) na região vestibular e anterior da maxila (Fig.1).

Figura 1: Hipertrofia inflamatória crônica (HIC).

O tratamento proposto, aceito e executado consistiu na excisão da lesão, seguida de um Enxerto Gengival Livre (EGL) na região da remoção, com o objetivo de promover o aprofundamento de vestíbulo, uma recuperação mais estável da mucosa e assegurar a presença de uma faixa de mucosa queratinizada.

Assepsia extraoral foi realizada com esfregaço de gaze com enxaguatório com oxigênio ativo (blue®m) no rosto e na região peribucal. Assepsia intraoral foi realizada com o mesmo enxaguatório com bochechos por 30 segundos.

Após a identificação e delimitação da área da lesão HIC (Figs.2A e 2B), realizou-se a anestesia dos nervos Maxilar Superior Anterior, Médio e Posterior direito e esquerdo, Nervo Naso Palatino e Nervo Palatino Maior direito e esquerdo, utilizando Mepivacaína e epinefrina 2% 1:100.000 (Mepiadre, DFL). Em seguida, foi realizada a incisão em bisel externo na região delimitada da lesão em duas áreas, com lâmina 15c (Swann Morton, Inglaterra), à direita e à esquerda, sem incisar o freio labial (Figs. 3A e 3B). Com o tecido removido (Fig. 4), procedeu-se à frenectomia utilizando a técnica de pinçamento duplo do freio labial e remoção total (Fig.5A), seguida de fenestração perióstica para maior elasticidade do retalho cirúrgico (Fig.5B).

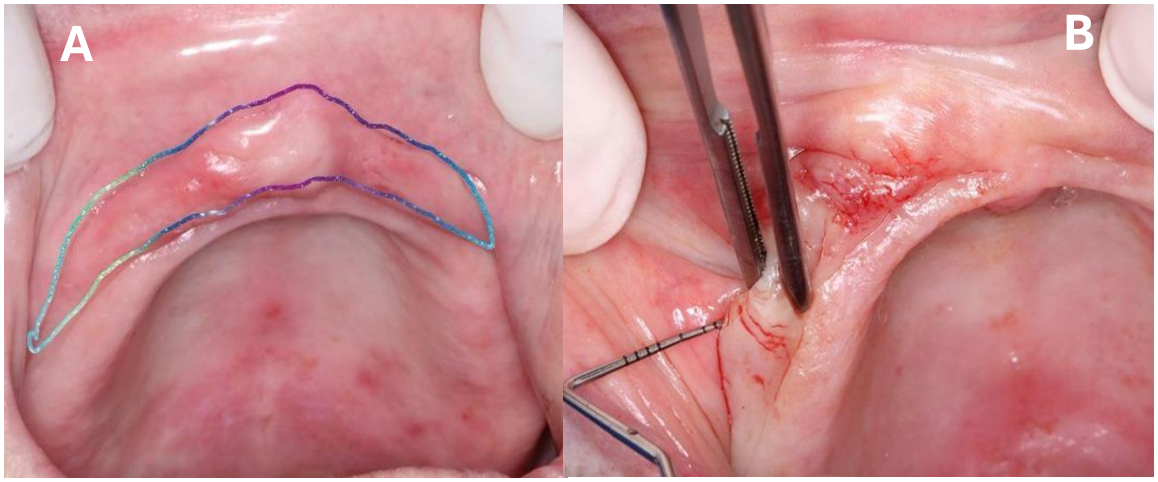

Figura 2: A: Identificando a lesão. B: Delimitando a lesão.

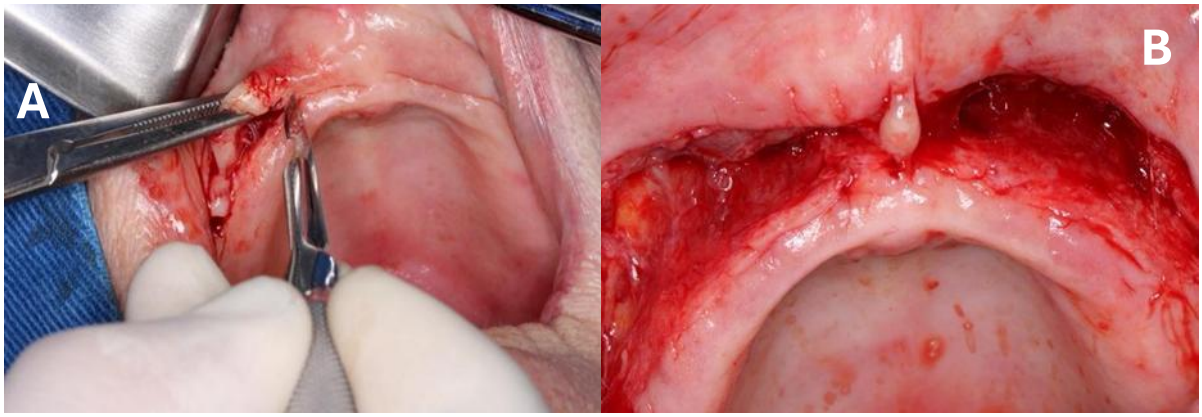

Figura 3: A: Incisão lado direito. B: Remoção bilateral preservando freio.

Figura 4: Tecido removido.

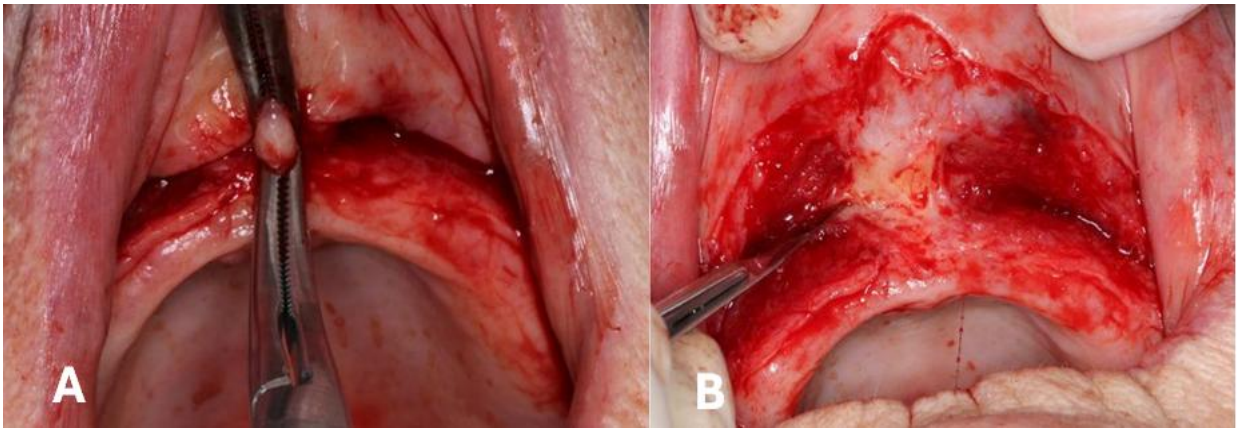

Figura 5: A: Frenectomia. B: Fenestração perióstica.

Para determinar a área de mucosa envolvida na remoção do enxerto, foi confeccionado um gabarito com o papel do fio sutura (Figs.6A e 6B). Com o gabarito em posição no palato, delimitou-se e realizou-se uma incisão com profundidade de 2 mm (fig.7A). Em seguida, a remoção do tecido gengival foi feita com auxílio de pinça Dietrich 18 mm em toda a extensão da área incisada (Figs.7B, 7C e 7D). Na área doadora, realizou-se a hemostasia por meio de sutura compressiva em "X" e aplicação de esponja de colágeno (Fig.8A), seguida da adaptação de curativo Ora-Aid, justaposto à área cruenta e estabilizado com sutura compressiva utilizando fio de Nylon Blue Monofilamento 6-0 (Techsuture). (Fig.8B).

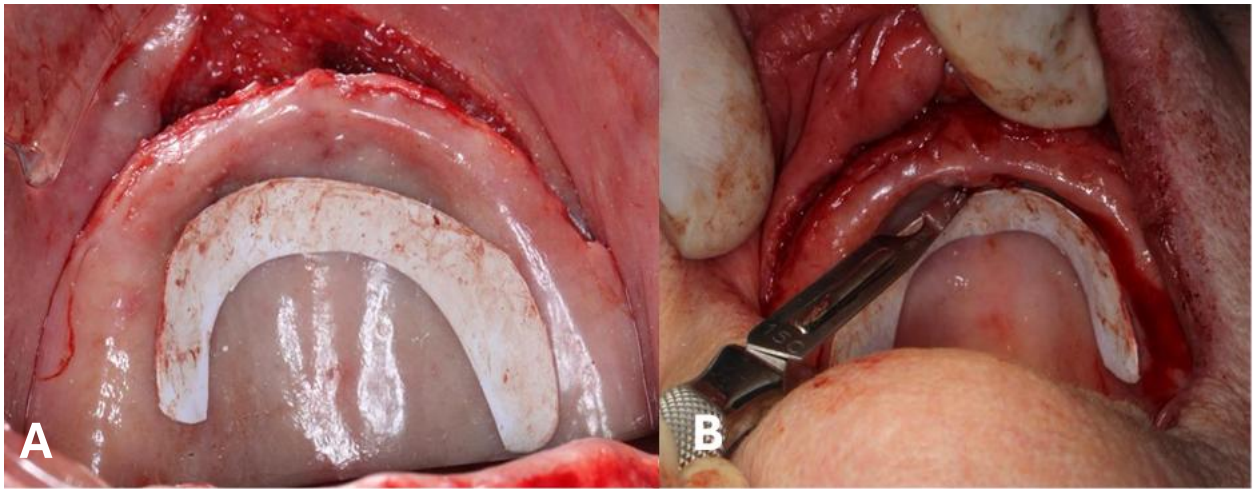

Figura 6: A: Confecção de Gabarito com papel do fio de sutura. B: Gabarito orientando a incisão.

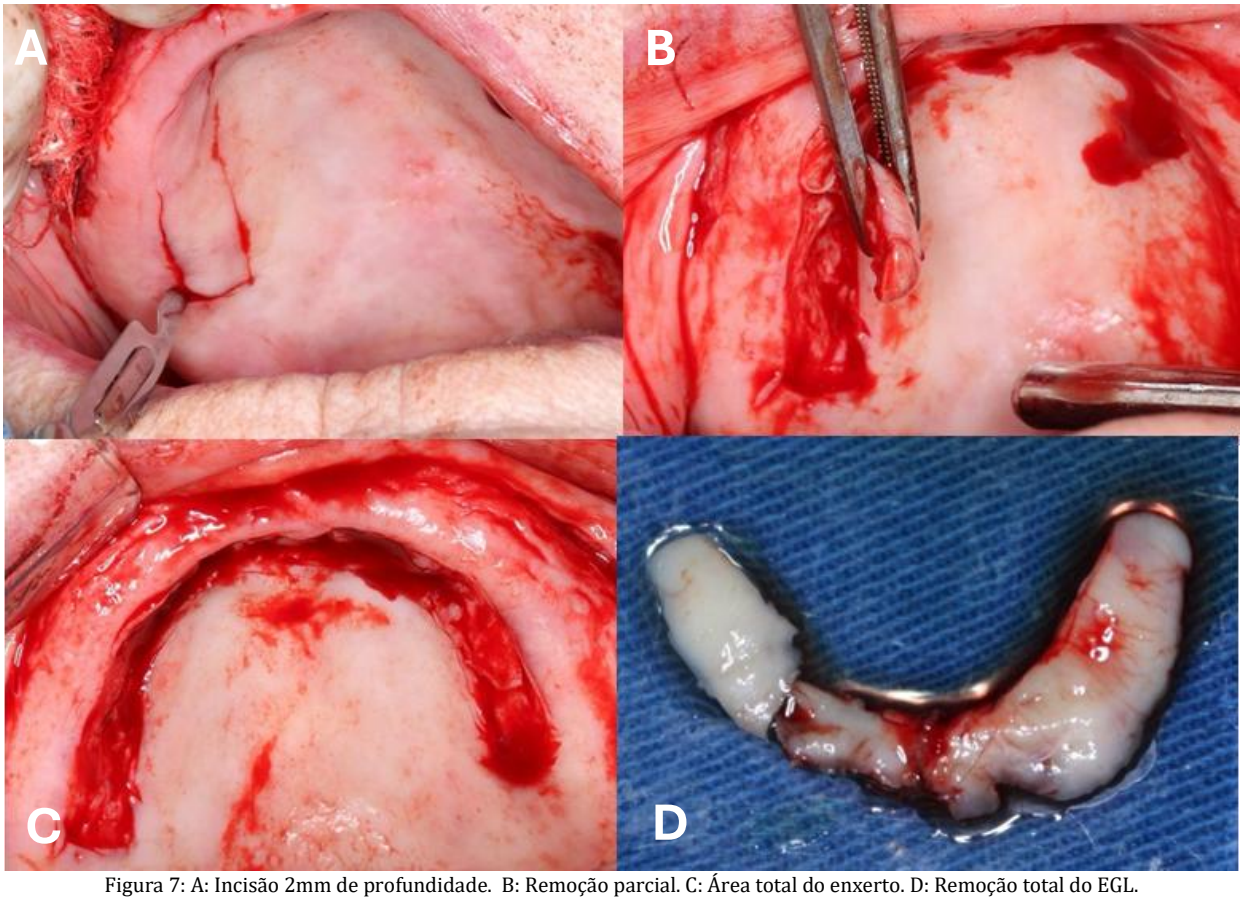

Figura 7: A: Incisão 2mm de profundidade. B: Remoção parcial. C: Área total do enxerto. D: Remoção total do EGL.

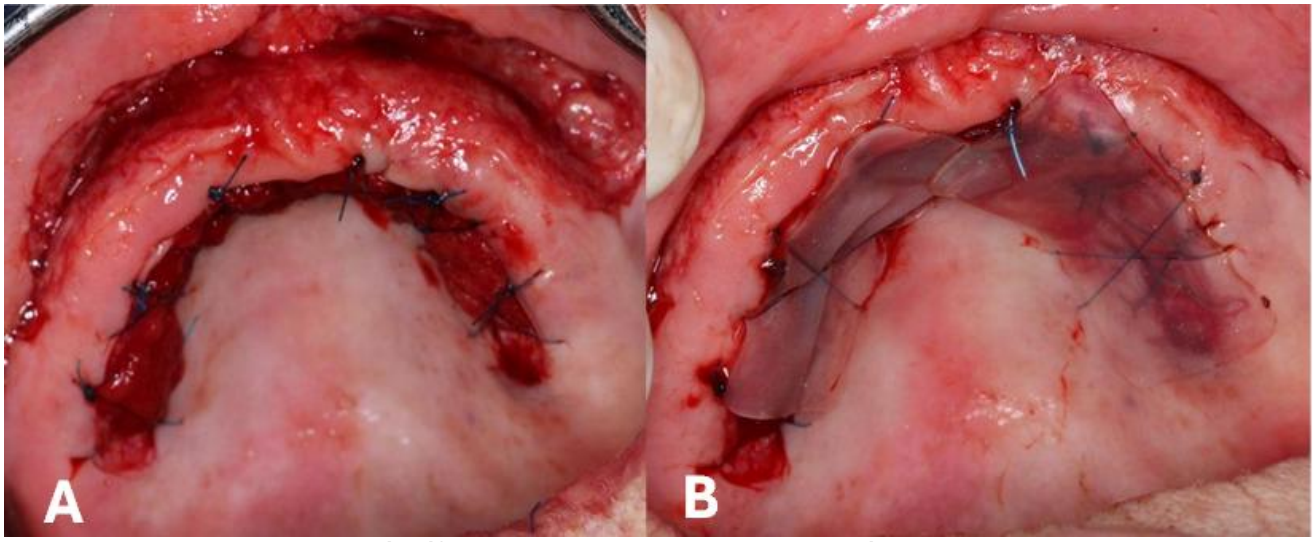

Figura 8: A: Esponja de colágeno e sutura compressiva. B: Curativo Ora-Aid e sutura compressiva em X.

Após o posicionamento do enxerto na área receptora, procedeu-se à fixação com parafusos para enxerto, iniciando-se pela extremidade direita (Fig.9A) e distribuindo-se seis parafusos equidistantes, a fim de otimizar a estabilidade durante a fase de cicatrização e garantir a imobilidade do EGL (Fig. 9B). Foram utilizados parafusos para enxerto gengival em titânio, de cabeça estendida de 1.6 x 5mm (Neodent Curitiba PR, Brasil) (Fig. 10). Para promover a cicatrização orientada no fundo do sulco labial, o retalho gengival foi suturado acima da porção superior do EGL (Fig.11).

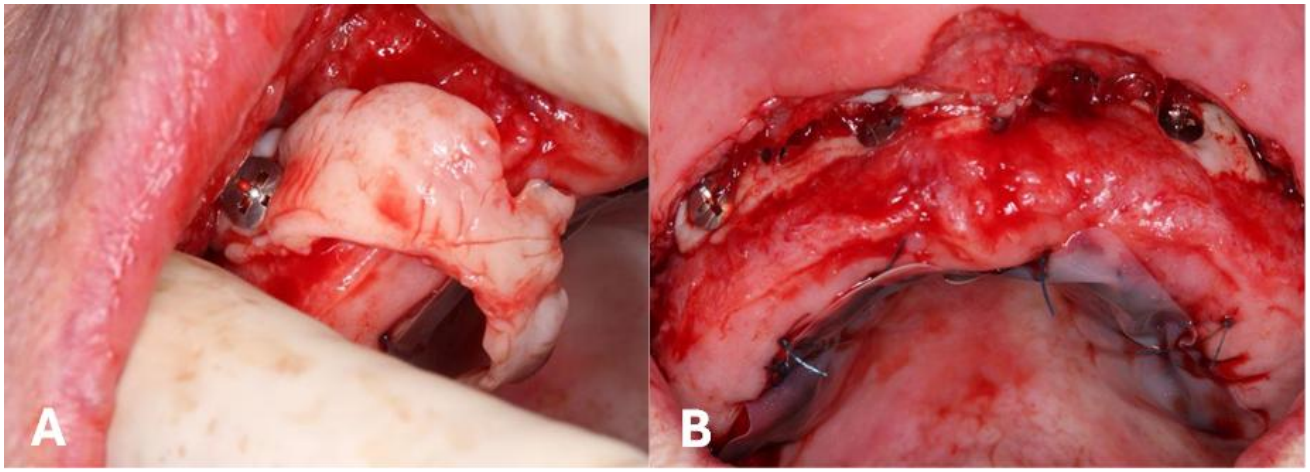

Figura 9: A: Fixação inicial. B: Instalação de seis parafusos equidistantes.

Figura 10: Parafuso para enxerto gengival em titânio

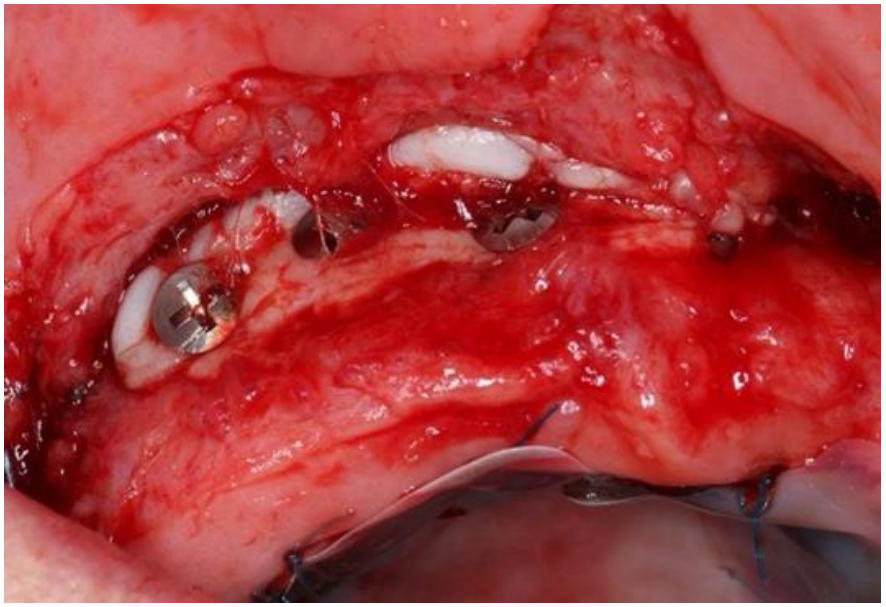
Figura 11: Sutura do retalho na porção superior do EGL

Ao concluir o procedimento, a prótese total mucossuportada foi reembasada com Soft Provisório (TDV) (Fig.12). As orientações pós-operatórias incluíram o uso de medicação analgésica (Dipirona 1 g a cada 12 horas), anti-inflamatório (Ibuprofeno de 600 mg a cada 8 horas por 4 dias/Spidufen® Lab. Zambon) e uso enxaguatório com oxigênio ativo (blue®m) três vezes ao dia.

Figura 12: Prótese total com reembasador soft.

O procedimento transcorreu sem intercorrências e nas revisões de 30 dias e de 14 semanas, foi identificada uma ótima cicatrização, estabilidade tecidual e presença de uma faixa de mucosa ceratinizada na posição antes ocupada pela lesão Hiperplásica inflamatória crônica. Os parafusos para fixação do enxerto não foram removidos, devido à estabilidade tecidual, biocompatibilidade do titânio e a supressão de uma etapa de morbidade cirúrgica (Figs.13 e 14).

Figura 13: Acompanhamento pós-operatório de 30 dias, mostrando estabilidade tecidual e presença de faixa queratinizada.

Figura 14: Acompanhamento pós-operatório de 14 semanas. Preservação do ganho da faixa de mucosa queratinizada e ausência de sinais de inflamação, recidiva da lesão original.

Discussão

O objetivo deste relato de caso clínico de tratamento de lesão hipertrófica inflamatória crônica com remoção da deformidade mucogengival e utilização de enxerto gengival livre (EGL) fixado com parafusos gengivais, foi analisar a eficácia desta técnica de fixação.

A hiperplasia inflamatória crônica é uma condição patológica frequente na cavidade oral, frequentemente associada a trauma protético, acúmulo de biofilme, resposta a corpos estranhos ou próteses mal adaptadas. Clinicamente, manifesta-se como uma lesão proliferativa, de consistência firme ou flácida, geralmente localizada na mucosa vestibular ou região de sulco, como observado na paciente deste caso, que apresentava aumento de volume em região anterior da maxila associado ao uso de prótese total mucossuportada com adaptação deficiente[8].

O tratamento convencional da hiperplasia inflamatória crônica envolve a excisão cirúrgica completa da lesão, com remoção do fator irritativo e correção do defeito tecidual subsequente. Em casos extensos, pode ser necessária a complementação com procedimentos de enxertia tecidual, como o enxerto gengival livre (EGL), com o objetivo de restabelecer a faixa de mucosa queratinizada, favorecer a cicatrização e prevenir recidivas[9,10].

Neste caso clínico, optou-se pela associação da remoção da lesão com a realização de um EGL, com o objetivo específico de reconstruir a mucosa perdida e promover uma zona estável e funcional de tecido queratinizado. A indicação do enxerto gengival livre também se justificou pela necessidade de aumentar a resistência da mucosa ao trauma protético, um fator de previsibilidade da reabilitação futura com prótese total mucossuportada.

Autores demonstram que o sucesso clínico do EGL depende diretamente da mobilidade do enxerto durante o período inicial de cicatrização, etapa essencial para a revascularização e integração ao leito receptor[1-3]. A movimentação do enxerto, especialmente em áreas com grande mobilidade muscular ou mucosa frouxa, pode comprometer a neoformação vascular e resultar em falhas parciais ou retração do enxerto.

Tradicionalmente, o EGL é fixado com suturas, o que pode gerar tensão nos bordos e instabilidade tecidual. Neste caso, foi proposta a fixação por meio de parafusos gengivais em titânio, com distribuição equidistante ao longo do enxerto. Essa estratégia visou maximizar a imobilização e assegurar maior

estabilidade mecânica, reduzindo o risco de micro movimentações durante o processo de cicatrização. Além disso, a fixação com parafusos gengivais mostrou ser mais rápida e fácil quando comparada com as suturas convencionais.

Estudos recentes sugerem que a fixação com parafusos gengivais pode ser uma alternativa eficaz à sutura convencional, especialmente em casos de enxertos amplos, em áreas móveis ou em situações clínicas que exijam maior controle da estabilidade tridimensional do tecido enxertado[4-6]. A manutenção dos parafusos no pós-operatório imediato, sem necessidade de remoção, também contribuiu para menor morbidade e maior conforto para a paciente, o que foi observado neste relato. No presente caso clínico, a fixação rígida por meio de parafusos proporcionou excelente imobilidade do enxerto, fator decisivo para o sucesso do procedimento, contribuindo para a integração tecidual adequada. Este caso clínico reforça a aplicabilidade clínica da técnica como alternativa à fixação convencional por sutura, especialmente em áreas que exigem maior controle da estabilidade tridimensional e previsibilidade dos resultados.

O acompanhamento pós-operatório da paciente com 30 dias e de 14 meses mostrou uma cicatrização adequada, ausência de sinais inflamatórios e formação de faixa contínua de mucosa queratinizada, o que demonstra a eficácia da técnica empregada e sua aplicabilidade em situações semelhantes.

Conclusão

A associação entre a excisão cirúrgica de hiperplasia inflamatória crônica e a utilização de enxerto gengival livre (EGL) fixado com parafusos gengivais demonstrou ser uma abordagem eficaz na reconstrução da mucosa queratinizada e na promoção de cicatrização estável em área de mobilidade e compressão protética.

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JOIS

CLINICAL STUDY

Predictability and oral health in clear aligner therapy for mixed dentition: a 12-month prospective study

ESTUDO CLÍNICO

Previsibilidade e saúde oral na terapia com alinhadores transparentes para dentição mista: um estudo prospectivo de 12 meses

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Abstract

Objective:This prospective clinical study evaluated the predictability of dental movement and oral health outcomes in children with mixed dentition treated with clear aligners. Methods: Orthodontic treatment was delivered using ClearCorrect® aligners. Standardized clinical documentation was obtained at pre-treatment (T1) and immediately post treatment (T2). Digital models were used to measure changes in arch perimeter, transverse dental movement at the cusp and gingival levels of the intercanine, first and second primary molars, and first permanent molars, as well as changes in dental spacing. Oral hygiene was assessed using the Simplified Visual Plaque Index and Modified Sulcus Bleeding Index. Root development was evaluated by crown-to-root ratio (C/R) and Nolla stages. Descriptive statistics were used to summarize outcomes. Results: Twenty children (7 Female, 13 Male; mean age, 8.5 ± 1.0 years) completed treatment with excellent compliance. The mean treatment duration was 9.6 ± 2.0 months. Predictability of arch perimeter increase was 32% in the upper arch and 58% in the lower arch. Transverse expansion predictability ranged from 42–54% at the gingival level and 51 65% at the cusp level, in the upper arch, and 42–58% and 46–95%, respectively, in the lower arch. Significant reductions in anterior crowding and midline diastemas were observed. Periodontal health remained stable, and root development progressed normally. Conclusion: ClearCorrect® aligners demonstrated clinically acceptable predictability of dental expansion in children with mixed dentition, achieving improvements in anterior crowding and midline diastemas, while also maintaining stable oral health status, and without compromising physiological root development.

Keywords: Appliances Removable; Dentition Mixed; Orthodontics Preventive; Tooth Movement; Orthodontics; Child; Tooth Root.

Resumo

Objetivo: Este estudo clínico prospectivo teve como objetivo avaliar a previsibilidade da movimentação dentária e os desfechos de saúde bucal em crianças com dentição mista tratadas com alinhadores transparentes. Métodos: O tratamento ortodôntico foi realizado utilizando alinhadores ClearCorrect®. A documentação clínica padronizada foi obtida antes do tratamento (T1) e imediatamente após o término (T2). Foram mensurados, em modelos digitais, o aumento do perímetro do arco, a movimentação dentária nos níveis de cúspide e gengival nas regiões intercanina, dos primeiros e segundos molares decíduos e dos primeiros molares permanentes, além das alterações nos espaços interdentários. A higiene bucal foi avaliada por meio do Índice Simplificado de Placa Visível e do Índice Modificado de Sangramento Gengival. O desenvolvimento radicular foi avaliado pela razão coroa/raiz (C/R) e pelos estágios de Nolla. Estatísticas descritivas foram usadas para resumir os resultados. Resultados: Vinte crianças (7 do sexo feminino e 13 do masculino; idade média de 8,5 ± 1,0 anos) completaram o tratamento com excelente adesão. A duração média do tratamento foi de 9,6 ± 2,0 meses. A previsibilidade do aumento do perímetro do arco superior foi de 32% e do arco inferior, de 58%. A previsibilidade da expansão transversal variou de 42–54% no nível gengival e de 51–65% no nível de cúspide, no arco superior, e de 42–58% e 46–95%, respectivamente, no arco inferior. Foram observadas reduções significativas no apinhamento anterior e nos diastemas medianos. A saúde periodontal manteve-se estável e o desenvolvimento radicular progrediu normalmente. Conclusão: Os alinhadores ClearCorrect® demonstraram previsibilidade confiável para a expansão dentária em crianças com dentição mista, promovendo melhorias no apinhamento anterior e nos diastemas medianos, mantendo a saúde bucal estável e sem comprometer o desenvolvimento radicular fisiológico.

Palavras-chave: Aparelhos ortodônticos removíveis; Dentição mista; Ortodontia Preventiva; Movimento dos Dentes; Ortodontia; Criança; Raiz do Dente

Introducion

Longitudinal Clear aligners have reshaped orthodontic practice by providing an esthetic and comfortable alternative for the management of malocclusions[1]. Their application has recently expanded to growing patients, particularly during the mixed dentition stage[2,3]. This developmental period, typically between 6 and 12 years of age, is characterized by the coexistence of primary and permanent teeth and represents a critical window for early diagnosis and intervention[4,5]. Timely management at this stage may prevent the progression of malocclusions, correct emerging irregularities, and eliminate functional interferences[6]. Evidence suggests that approximately 15% of malocclusions can be fully corrected and nearly half significantly improved when treated during mixed dentition[7]. Early intervention has also been associated with improved oral health outcomes[8] and enhanced psychosocial well-being[9]. Nonetheless, the optimal timing for intervention remains debated and appears to depend on malocclusion type, severity, and patient adherence[10-12].

Crowding is one of the most common indications for orthodontic intervention during the mixed dentition stage[13]. Traditionally, space maintenance and arch expansion have been managed with fixed appliances[14]. More recently, clear aligners have emerged as a viable alternative for addressing incisor crowding at this stage[15]. Supported by digital planning and the use of attachments, aligners allow controlled dental expansion, modification of arch form, and improved transverse coordination between arches[16,17]. Clinical evidence demonstrates that aligners can achieve correction of anterior crowding in both permanent and mixed dentition, with predictability rates ranging from 48.7% to 61.1%[16,18-21].

Root resorption represents a critical safety concern in orthodontics, particularly in children, due to ongoing root development[22]. Radiographic monitoring is essential to ensure that applied orthodontic forces do not compromise physiological processes[23]. Available evidence indicates that clear aligners are associated with minimal root resorption[24] and, in adults, lower rates compared to fixed appliances[25]. However, data in growing patients remain scarce, highlighting the need for prospective clinical investigations[1].

Accordingly, this prospective clinical study aimed to evaluate the predictability of dental expansion in children with mixed dentition treated with clear aligners by comparing virtually planned movements with those achieved, and to assess oral health outcomes, including oral hygiene and root development.

Material e methods

Study Design and Sample

Material e methods Study Design and Sample The study protocol was reviewed and approved by the Ethics Committee of Evangelical Mackenzie College of Paraná (approval number: 5.910.189) and conducted in accordance with the Declaration of Helsinki. All participants were recruited from a private orthodontic practice in Curitiba, Paraná, Brazil. Written informed consent was obtained from the parents or legal guardians of all participants, and assent was obtained from the children when appropriate. Treatments were delivered by a single orthodontist between March 2023 and October 2024.

This prospective, single-arm study aimed to evaluate the clinical effectiveness of ClearCorrect® (ClearCorrect, Round Rock, Texas) aligner therapy in children aged 6 to 10 years presenting with mixed dentition or unerupted permanent second molars requiring orthodontic intervention. Aligners were thermoformed from patient-specific digital prescriptions using ClearQuartz® material (BPA-free, ISO 10993-compliant). No control group or comparator was included.

Exclusion criteria were: inadequate oral hygiene; allergies or hypersensitivity to copolyester or polyurethane; active periodontitis according to the 2017 World Workshop classification[26]; severe systemic or metabolic disease; medications affecting bone metabolism; temporomandibular joint disorders; untreated dental caries; sleep disorders preventing nighttime aligner use; ankylosed teeth; and fully erupted adult dentition.

All enrolled patients underwent orthodontic treatment with ClearCorrect® aligners. Standardized clinical documentation was obtained at pre-treatment (T1) and immediately post-treatment (T2), including intraoral photographs (frontal occlusion, right and left lateral views, upper and lower occlusal views), extraoral photographs (frontal at rest, frontal smiling, lateral profile), and periapical radiographs of the maxillary and mandibular central incisors. Radiographs were acquired at a specialized imaging center to ensure standardized quality and diagnostic consistency.

Pretreatment digital scans (T1) of the upper and lower arches were obtained using the Straumann® Virtuo Vivo™ intraoral scanner (Straumann Group, Basel, Switzerland). Treatment planning was

conducted using ClearCorrect ClearPilot®, integrating intraoral scans, standardized intraoral and extraoral photographs, and a complete radiographic series, including periapical radiographs, panoramic radiography, and lateral cephalometric

(profile) radiographs. The orthodontist reviewed and approved all treatment plans in collaboration with a dedicated ClearCorrect technician, and each aligner series was individually fabricated according to the patient's dental morphology and clinical requirements.

Aligners were changed every two weeks, and follow-up visits occurred at four-week intervals to monitor progress, implement clinical adjustments, and reinforce compliance. Refinements or treatment revisions were performed as needed based on clinical evaluation. Immediately following completion of the active phase, posttreatment digital scans (T2) were acquired to evaluate predictability of planned tooth movements.

Assessment of Initial Malocclusion and Treatment Progress

Initial malocclusion was evaluated using pretreatment digital models. Permanent molar relationships were classified according to Angle's system. Treatment progress was assessed on both arches through detailed digital model analysis. Treatment complexity and progression were indirectly evaluated by recording the number of aligner steps and refinements required per patient.

Arch perimeter was measured along the curvature of the dental arch, from the mesial of the first permanent molar on one side to the mesial of the contralateral first permanent molar (Fig. 1). Planned and achieved arch perimeter increases were calculated for each patient by measuring the difference in arch perimeter between models.

Figure 1: Measurement of arch length along the dental arch from the mesial of the first permanent molar on one side to the mesial of the contralateral first permanent molar.

All treatment plans were reviewed and approved by the treating orthodontist before aligner fabrication. Digital treatment planning was performed using the ClearPilot® platform in collaboration with the manufacturer's technical support team. Transverse expansion was evaluated at the intercanine and intermolar regions of the deciduous canines, deciduous molars, and permanent first molars (Fig. 2).

For each tooth, measurements were obtained at two vertical reference levels: cusp tip (representing the occlusal/incisal dimension) and cervical/gingival

level (at the cementoenamel junction, representing basal arch width). Planned corrections were calculated by comparing initial and final virtual setup models, while achieved corrections were obtained from actual posttreatment digital scans. Predictability rates were expressed as the ratio between achieved and planned corrections at each anatomical reference point for both arches. Spacing pattern changes, including diastema closure and crowding reduction, were assessed as present or absent.

All measurements were performed using the ClearPilot® measurement tool.

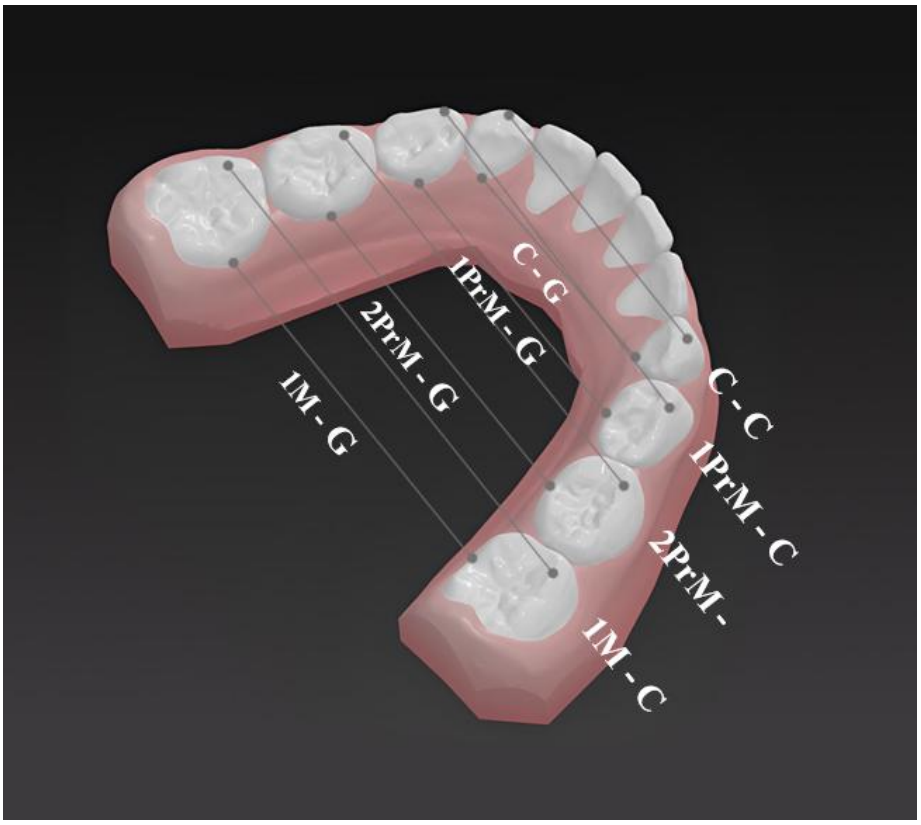

Figure 2: Evaluation of transverse expansion at the intercanine and intermolar regions for deciduous canines, deciduous molars, and permanent first molars.

Subtitle: : C-G, intercanine distance at the gingival level; C-C, intercanine distance at the cusp level; 1PrM-G, inter–1st primary molar distance at the gingival level; 1PrM-C, inter–1st primary molar distance at the cusp level; 2PrM-G, inter–2nd primary molar distance at the gingival level; 2PrM-C, inter–2nd primary molar distance at the cusp level; 1M-G, inter–1st permanent molar distance at the gingival level; 1M-C, inter–1st permanent molar distance at the cusp level.

Oral Hygiene Assessment

Oral hygiene was assessed using the Simplified Visual Plaque Index (VPI), recorded dichotomously (presence/absence) at six surfaces of the Ramfjord index teeth (16, 21, 24, 36, 41, and 44) and expressed as the percentage of plaque-positive sites. Additionally, the Modified Sulcus Bleeding Index (mSBI) was calculated as the proportion of sites exhibiting bleeding on probing (Papapanou et al., 2018). Mean mSBI scores were reported for each patient at baseline, treatment initiation, and at 6- and 12-month follow-ups, interpreted as: 0–10% = healthy gingiva, 11–30% = mild inflammation, 31–50% = moderate inflammation, and >50% = severe inflammation. Oral hygiene was further categorized according to clinical judgment into four levels: excellent (absence of plaque and bleeding), good (plaque present without bleeding), satisfactory (localized plaque and bleeding), and poor (generalized plaque and bleeding)[27].

Root Development

Root development was assessed using two complementary approaches: crown-to-root (C/R) ratio

analysis and Nolla stage assessment. Pre- and post-treatment periapical radiographs of the maxillary and mandibular central incisors(#11, #21, #31, and #41) were retrieved. Clinical crown length (incisal edge to cementoenamel junction) and visible root length (cementoenamel junction to radiographic apex) were measured to the nearest 0.1 mm using ImageJ software (National Institutes of Health, Bethesda, MD, USA), and C/R ratios were calculated for each tooth at T1 and T2. Root development was classified according to Nolla's ten-stage scale (0 = no calcification; 10 = closed apex) by a single calibrated examiner. An increase of one or more stages from T1 to T2 was considered physiological root growth, whereas stage stability or regression, in conjunction with increased C/R ratios, was interpreted as potential treatment-related resorption.

Statistical Analysis

All statistical analyses were performed using Jamovi (The Jamovi Project, Sydney, Australia), an open-source statistical software built on the R environment. Descriptive statistics (mean, standard deviation, and percentages) were calculated to summarize treatment performance and safety outcomes.

Results

A total of 31 children were initially screened for participation in the study. Eleven subjects were excluded because they did not meet one or more of the inclusion or exclusion criteria. Consequently, 20 children (7 female, 13 male) met the eligibility requirements and were enrolled. The mean age of the included participants was 8.5 ± 1.0 years (range 6-10 years). None presented clinically relevant health conditions within the past five years, and none had undergone previous orthodontic treatment. Clinical examination confirmed the presence of healthy oral tissues, supporting the inclusion of a homogeneous, developmentally appropriate pediatric population.

From a dentoalveolar standpoint, all patients demonstrated arch form discrepancies requiring intervention. Class II molar relationships, including subdivisions, predominated, while no cases of Class III were observed. Correction of molar relationships was not planned at this stage; the interceptive therapy focused on improving arch form to support optimal development of the permanent dentition. Malocclusion-related indications included anterior crowding and midline diastemas, particularly in the upper arch (Table 01). Craniofacial parameters such as facial profile and symmetry were within normal range for all participants. Minor functional alterations (e.g., jaw clicking, atypical speech) were observed in a small subset of patients, and the majority exhibited competent lip seal and nasal breathing at rest (Table 01).

Mean mSBI values were within the healthy range (0–10%), with a transient increase to 11% at the 6-month follow-up, indicating mild gingival inflammation.

Table 1 - Distribution of Occlusal, Facial, and Functional Characteristics of the Patients Included (N=20)

Orofacial Characteristics	N (20)	%
Molar relationship		
Class I	*5*	25%
Class II	*8*	40%
Class II subdivision	*7*	35%
Class III	*0*	0%
Class III subdivision	*0*	0%
Occlusal Characteristics (Reasons to treat)		
Upper Midline Diastema	*8*	40
Lower Midline Diastema	*3*	15
Upper Incisor Crowding	*11*	55
Lower Incisor Crowding	*8*	40
Facial and Functional Parameters		
Straight Facial Profile	*20*	100
Facial Symmetry	*20*	100
Sealed Lips at rest	*18*	90
Jaw Pain or clicking	*2*	10
Speech Atypical	*1*	5
Nasal Breathing	*20*	100

Treatment compliance was high, with 100% of the patients having reported to use the aligners as prescribed by the orthodontist, and no dropouts or treatment discontinuations occurred. During the active treatment phase, patients wore the aligners for 22 hours or more per day, removing them only for meals and oral hygiene. After completion of active tooth movements, four patients (20%) were instructed to transition to night-time wear (6–8 hours/day), as part of the retention phase.

The mean number of planned steps was 17 (SD = 4), corresponding to an estimated treatment duration of 7.9 months. The actual mean number of steps was 25 (SD = 7), with an average treatment duration of 9.6 months. Revisions were frequently incorporated into the treatment process: 5% of patients required none, 40% required one, 45% required two, and 10% required three revisions. The revisions were based on clinical monitoring and aimed at improving aligner fit, tracking, and retention. On average, revisions were introduced at step 15 (SD = 6). Horizontal engagers were applied in all cases, whereas vertical engagers were selectively used to facilitate specific tooth movements.

Four patients developed a deleterious habit of biting on the aligner after it became dislodged during normal use, resulting in deformation characterized by flattening of the aligner surface. This was attributed to reduced aligner retention caused by the absence of fully erupted permanent teeth, a characteristic of this developmental stage. Although no harm to the patients was observed, the aligner deformation compromised aligner function and required an adjustment of the aligner wear protocol from 14 days to 10 days, which resolved the issue in all instances.

All subjects exhibited a straight facial profile and facial symmetry at both T1 and T2 (100%). The nasolabial angle was normal in all cases. At rest, 90% of participants had sealed lips at T1, increasing to 100% at T2. Jaw pain or clicking was reported in 10% of subjects at T1, with no such report at T2. Speech was normal in 95% of participants at T1 and in 100% at T2.

The predictability rate of upper arch perimeter increase was 32% (planned: 2.11 ± 1.29 mm; actual: 0.67 ± 1.05 mm). For the lower arch, the predictability rate was 58% (planned: 1.83 ± 1.14 mm; actual: 1.01 ± 1.04 mm).

Transverse expansion was observed across all measured regions in both arches. For the upper arch, predictability at the gingival level ranged from 42% (first permanent molars) to 54% (primary canines), and at the cusp level from 51% (first permanent molars) to

65% (primary canines), with mean planned expansions between 3.36 and 4.62 mm and achieved expansions between 1.41 and 2.99 mm (Table 02). In the lower arch, predictability at the gingival level ranged from 42% (first permanent molars) to 58% (primary canines), and at the cusp level from 46% (first permanent molars) to 95% (primary canines), with planned expansions between 2.46 and 3.80 mm and achieved expansions between 1.13 and 3.02 mm (Table 03).

Table 2 - Predictability Rate of Transverse Expansion in the Upper Arch

	Planned		Actual		Difference		Predictability
Distance (mm)	Mean	SD	Mean	SD	Mean	SD	(%)
C-G	2.46	1.15	1.42	1.14	1.05	1.10	58%
C-C	2.93	1.55	2.78	2.48	0.15	1.60	95%
1PrM-G	3.40	1.26	1.85	1.40	1.56	1.60	54%
1PrM-C	3.80	0.94	3.02	1.37	0.78	1.31	79%
2PrM-G	3.36	1.05	1.49	0.86	1.88	0.95	44%
2PrM-C	3.51	0.94	2.17	1.03	1.34	0.91	62%
1M-G	2.71	1.00	1.13	0.75	1.58	0.97	42%
1M-C	3.03	1.14	1.38	1.70	1.65	1.58	46%

Subtitle: C-G, intercanine distance at the gingival level; C-C, intercanine distance at the cusp level; 1PrM-G, inter–1st primary molar distance at the gingival level; 1PrM-C, inter–1st primary molar distance at the cusp level; 2PrM-G, inter–2nd primary molar distance at the gingival level; 2PrM-C, inter–2nd primary molar distance at the cusp level; 1M-G, inter–1st permanent molar distance at the gingival level; 1M-C, inter–1st permanent molar distance at the cusp level.

Table 3 - Predictability Rate of Transverse Expansion in the Lower Arch

	Planned		Actual		Difference		Predictability
Distance (mm)	Mean	SD	Mean	SD	Mean	SD	(%)
C-G	4.29	0.95	2.31	1.38	1.98	1.63	54%
C-C	4.62	0.70	2.99	1.52	1.64	1.25	65%
1PrM-G	4.17	0.60	1.86	1.26	2.31	1.30	45%
1PrM-C	4.54	0.68	2.67	1.36	1.87	1.32	59%
2PrM-G	4.15	0.59	2.16	1.06	1.99	1.06	52%
2PrM-C	4.40	0.69	2.50	1.24	1.91	1.11	57%
1M-G	3.36	1.19	1.41	0.79	1.95	1.29	42%
1M-C	3.80	1.38	1.92	1.17	1.88	1.34	51%

Subtitle: C-G, intercanine distance at the gingival level; C-C, intercanine distance at the cusp level; 1PrM-G, inter–1st primary molar distance at the gingival level; 1PrM-C, inter–1st primary molar distance at the cusp level; 2PrM-G, inter–2nd primary molar distance at the gingival level; 2PrM-C, inter–2nd primary molar distance at the cusp level; 1M-G, inter–1st permanent molar distance at the gingival level; 1M-C, inter–1st permanent molar distance at the cusp level.

Significant improvements in midline diastemas and incisor crowding were observed following the intervention. In the upper arch, the prevalence of midline diastema decreased from 40% (8/20) at T1 to 0% at T2 (p = 0.008), while incisor crowding decreased from 55% (11/20) to 5% (1/20; p = 0.002). In the lower arch, the prevalence of incisor crowding decreased significantly from 40% (8/20) to 5% (1/20; p = 0.02), whereas lower midline diastema was completely eliminated, decreasing from 15% (3/20) to 0% (p = 0.25).

Mean mSBI values were generally within the healthy range (0–10%), with a transient increase to 11% at the 6-month follow-up, indicating mild gingival inflammation. By 12 months, values returned to below 10%, reflecting restored gingival stability. Plaque accumulation remained low at all time points, with the Plaque Index decreasing from 5.0% at screening to 0.4% at treatment initiation and remaining below 8% at both the 6- and 12-month follow-ups (Table 04).

Table 4 - Mean ± Standard Deviation values of oral hygiene indices across evaluation periods

Evaluation Period	mSBI (%)	Plaque Index (%)
Screening visit	1.7 ± 7.5	5.0 ± 22.4
Treatment Start (T1)	1.7 ± 7.5	0.4 ± 1.9
6-Month Follow-up	11.0 ± 10.0	7.5 ± 30.8
12-Month Follow-up (T2)	10.0 ± 9.0	7.5 ± 24.5

Subtitles: mSBI - Modified Sulcus Bleeding Index; % - percentage.

All evaluated teeth exhibited a slight reduction in crown-to-root ratio (C/R), with mean differences ranging from –0.11 to –0.16. The changes were statistically significant for #21 (p = 0.03) and #31 (p = 0.04), whereas #11 (p = 0.06) and #41 (p = 0.10) showed a non-significant trend toward ratio reduction (Table 05).

At T1, mean Nolla stages ranged from 6.5 ± 0.5 for #11 and #21 to 7.3 ± 0.5 for #31. By T2, all teeth exhibited marked advancement, with mean stages increasing to 7.7 ± 0.5 (#11), 7.5 ± 0.5 (#21), 8.8 ± 0.4 (#41), and 8.6 ± 0.5 (#31). The mean differences (T2 – T1) ranged from 1.0 to 1.6, confirming consistent and substantial root maturation across all evaluated teeth (Table 06 Fig. 3)

Table 5 - Mean ± Standard Deviation of Crown-to-root (C/R) ratio Pre - and Post-treatment.

Tooth #	T1	T2	Mean Difference (T2 - T1)
11	1.16 ± 0.23	1.01 ± 0.16	-0.14
21	1.13 ± 0.15	0.98 ± 0.20	-0.16
41	1.04 ± 0.23	0.92 ± 0.14	-0.12
31	1.03 ± 0.15	0.91 ± 0.10	-0.11

Subtitles: T1 – Pre- treatment; T2 - Post-treatment.

Table 06. Mean ± Standard Deviation of Nolla Stages Pre- and Post-treatment.

Tooth #	T1	T2	Mean Difference (T2 - T1)
11	6.5 ± 0.50	7.7± 0.50	1.2
21	6.5 ± 0.50	7.5 ± 0.50	1.0
41	7.2 ± 0.40	8.8 ± 0.1.6	1.6
31	7.3 ± 0.50	8.6 ± 0.50	1.3

Subtitles: T1 – Pre-treatment; T2 - Post-treatment.

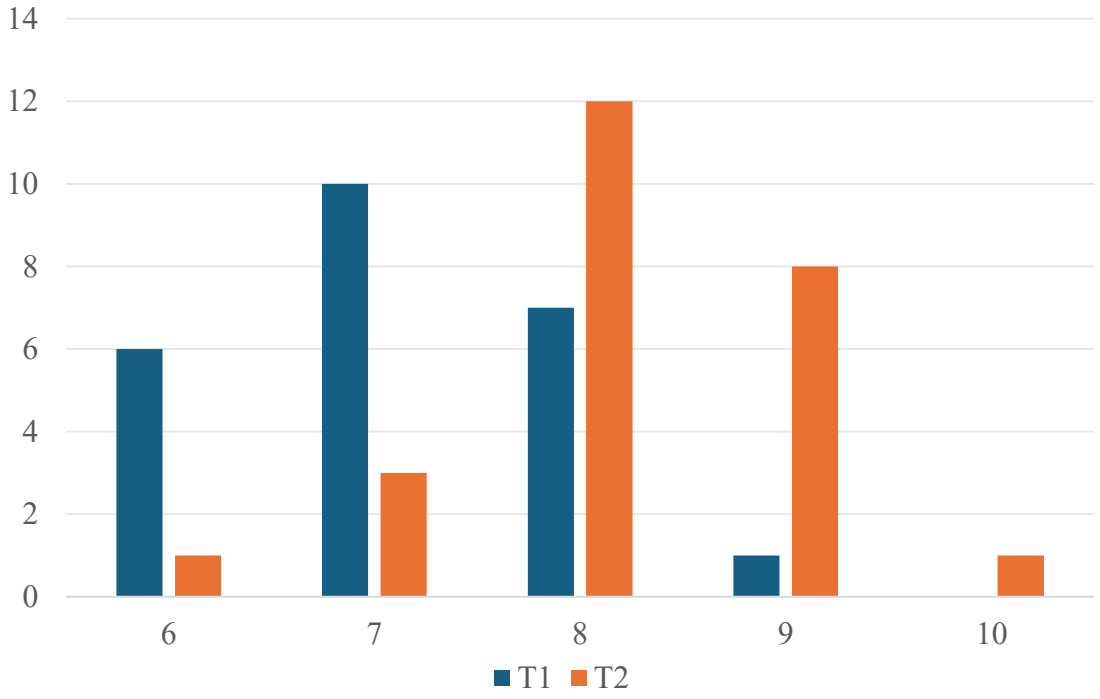

Figure 3: Distribution of Nolla stages for upper and lower incisors at pre (T1) and pos-treatment (T2).

Discussion

l. This prospective clinical study demonstrated that ClearCorrect® aligners are a clinically feasible and safe option for interceptive orthodontic treatment in patients with mixed dentition, incorporating radiographic safety endpoints and treatment predictability. Treatment planning aimed at supporting arch development, managing malocclusion during early dental transitions, and establishing favorable conditions for subsequent phases of orthodontic correction.

Treatment compliance is a critical determinant of successful removable aligner therapy, particularly in pediatric populations[28]. Although dependence on patient cooperation is a recognized limitation of removable appliances, the present study demonstrated 100% compliance, with no dropouts or treatment discontinuations, indicating that appropriately motivated children can achieve excellent outcomes.

While four patients developed a deleterious habit of biting on the aligner after it became dislodged due to reduced aligner retention, resulting in flattening of the aligners´ occlusal surface, this was resolved by

shortening the wear protocol to 10 days, with no clinical impact or harm to the patients. In such cases, reducing the interval between aligner changes, potentially in combination with smaller programmed tooth movements per step, may help prevent complications and enhance treatment efficiency. Careful patient selection and regular clinical monitoring remain essential to achieving favorable outcomes.

Most patients (95%) required at least one refinement during treatment, with an average of 25 aligners used over 9.6 months, exceeding the initially planned 17 steps. It is important to note that refinements are not only expected but often necessary in clear aligner therapy, particularly in pediatric patients[1,29]. This is due to the dynamic nature of tooth eruption, potential variations in compliance, and biological remodeling during growth[1,30,31]. In a comparable study on interceptive aligner treatment with Invisalign First®, Lione et al. (2021)[16] reported the need for refinement in 90% of cases, underscoring that mid-course adjustments are a common and essential component of successful treatment in this age group. These findings are further supported by large-scale data from adult and adolescent populations[32]. In a multicenter retrospective study involving 500 patients treated with clear aligners, Kravitz et al. (2023)[32] found that only 6% completed treatment without any refinement, with an average of 2.5 refinement scans per patient and a 17.2% conversion rate to fixed appliances. This data reinforces that refinements should be anticipated as a standard component of aligner therapy, particularly in complex or growing dentitions[1,32].

Arch perimeter increases were less predictable, with mean accuracies of 32% in the upper arch and 58% in the lower arch. This limited predictability may be influenced by the transitional phase of mixed dentition[1] and indicates that sagittal development during this period is biomechanically more challenging, potentially requiring additional strategies to achieve the planned outcomes.

Regarding the predictability of the planned dental expansion, clinically favorable outcomes were observed. The highest predictability was seen for mandibular intercanine distance at the cusp level (C-C: 95%), followed by the inter-1st primary molar cusp level (1PrM-C: 79%). Predictability of transverse dental expansions ranged from 42% to 65% in both arches, with slightly higher averages in the upper arch. These results are consistent with Levrini et al. (2024)[21], who reported predictability rates of 59–67% at the cuspidal level and 45–53% at the gingival level for upper dental expansion using clear aligners (Invisalign First®). The difference in predictability between cusp and gingival levels indicates that clear aligners primarily produce dentoalveolar changes through buccal tipping of the teeth, rather than true maxillary skeletal expansion. This pattern aligns with orthodontic expansion protocols that do not apply orthopedic forces[33].

Kim et al. (2024)[34] observed variation in arch expansion predictability depending on arch and tooth region, while Galluccio et al. (2023)[33] reported an overall accuracy of 70.88% for upper arch expansion with clear aligners, independent of tooth region. Similarly, Lu (2023)[35] found an average predictability of 71.6% for maxillary dentoalveolar expansion, and Bruni et al. (2025)[36] reported that expansion outcomes in mixed dentition ranged from 65% to 75%, influenced by anchorage design and attachment use. Collectively, these findings suggest that although clear aligners can effectively support transverse development in children, fully achieving planned movements, especially in posterior segments or when sagittal gain is desired, remains a clinical challenge, regardless of the aligner system employed[33,36-38].

The significant reductions in midline diastemas and incisor crowding observed in both arches underscore the clinical efficacy of the intervention. In the upper arch, midline diastemas were completely closed, and upper incisor crowding was markedly reduced, aligning with findings from Van Tam et al. (2025)[39], who reported high predictability in closing anterior diastemas using clear aligners in adults with high aesthetic expectations. Similarly, in the lower arch, the complete elimination of midline diastemas and substantial reduction in lower incisor crowding indicate that the applied orthodontic approach effectively addresses common malocclusions in mixed dentition. In the current study, anterior crowding was resolved in 95% of patients, consistent with the randomized clinical trial by Merino da Silva et al. (2023)[40], which found equivalent effectiveness between clear aligners and fixed appliances for incisor alignment. Additionally, Jee et al. (2025)[41] demonstrated that enhanced force systems in clear aligners can efficiently close maxillary anterior diastemas, further supporting the effectiveness of the treatment modality.

Oral hygiene remained stable throughout the study, with consistently low plaque accumulation (<8%) and gingival bleeding within the healthy to mildly inflamed range (mSBI ≤11%). A transient peak in bleeding was observed at 6 months but decreased to below 10% by the end of treatment, indicating controlled gingival inflammation. These findings confirm that removable appliances, such as

ClearCorrect® aligners, do not negatively impact periodontal health in children and may help maintain oral hygiene[42-44]. The removability of these appliances is particularly advantageous in pediatric populations, who often exhibit lower compliance with oral hygiene routines or have motor skill limitations that hinder effective cleaning[45]. Similar outcomes have been reported with Invisalign First®, where interceptive treatment did not cause detrimental changes to the gingival margins[1]. Furthermore, comparative studies suggest that clear aligners provide periodontal advantages over fixed appliances, with significantly lower plaque accumulation and bleeding indices in adolescent patients[46,47].

Monitoring crown-to-root (C/R) ratio addresses a key safety concern in growing patients, by assessing root resorption during orthodontic treatment[48]. Periapical radiographs revealed mild reductions in C/R ratio, with mean changes ranging from −0.11 to −0.16. These decreases were expected, reflecting normal physiological root elongation during dental development, without being associated with adverse outcomes[49]. Concurrently, Nolla stage analysis demonstrated ongoing root development in all evaluated incisors (mean increase from 1.0 to 1.6 stages), supporting the conclusion that orthodontic forces did not compromise physiological rhizogenesis. In contrast, fixed appliances are associated with a higher risk of apical root resorption[50], particularly in patients undergoing active root development. Overall, these findings are consistent with recent evidence indicating that ClearCorrect® therapy may reduce the risk of apical root resorption, when compared to fixed appliances[51].

Despite these encouraging results, certain precautions should be considered. Younger children or patients exhibiting parafunctional habits may experience increased mechanical stress on the aligners or show reduced compliance, potentially affecting treatment outcomes[52,53] (Zhou et al., 2024; Perilo et al., 2023; Kalaoglu et al., 2024). In such cases, reinforced caregiver guidance, frequent reminders, and shorter wear intervals can help optimize aligner performance[54,55]. Additionally, careful patient selection remains a critical determinant of success, with strong family support and consistent clinical monitoring contributing to favorable results[1,53-55]. These considerations are consistent with the principles of interceptive orthodontics and further support the use of clear aligners as a first-phase intervention within two-step treatment protocols[45,56].

Among the limitations of this study, it is important to note that direct comparisons with fixed appliances or other aligner systems were not feasible due to the study design (single-arm prospective study without a control group). Nevertheless, the clinical outcomes observed, including space gain, improved incisor alignment, maintained oral hygiene, and high patient tolerability, are consistent with findings reported in the literature. These benefits outweigh the minimal and self-limiting risks observed. Overall, ClearCorrect® Aligner Therapy in this population seems to be favorable, particularly given their removable, aesthetic, and hygiene-compatible characteristics.

Conclusion

ClearCorrect® clear aligners demonstrated reliable predictability of dental expansion in children with mixed dentition. Predictability was higher for lower arch movements and cusp-level transverse expansions. Treatment led to significant improvements in anterior crowding and midline diastemas, with high patient compliance and a limited need for refinement.

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JOIS

CASE REPORT

Virtual surgical planning and 3d simulation with augmented reality in mandibular monostotic fibrous dysplasia: a case report

RELATO DE CASO

Planejamento cirúrgico virtual e simulação 3D com realidade aumentada na displasia fibrosa monostótica da mandíbula: relato de caso

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Abstract

Monostotic fibrous dysplasia (MFD) is a benign, non-hereditary skeletal disorder characterized by the replacement of normal bone with fibrous tissue and immature woven bone. Although the craniofacial region is frequently affected, mandibular involvement is less common and may pose significant clinical and surgical challenges, particularly in recurrent or symptomatic cases. This case report describes a patient with mandibular MFD presenting lesion progression and persistent neuropathic pain following initial surgery. A second surgical intervention was subsequently performed using advanced digital technologies, including virtual surgical planning, 3D modeling and printing, intraoperative simulation guided by augmented reality, and customized cutting guides. Postoperative computed tomography confirmed high fidelity to the surgical plan and improvement in facial symmetry. This case highlights important advances in the application of digital technologies in oral and maxillofacial surgery, demonstrating increased precision, improved aesthetic outcomes, and enhanced anatomical preservation. To our knowledge, this is one of the few documented cases of recurrent mandibular fibrous dysplasia treated using digital surgical simulation and multiplanar cutting guides. These findings suggest that virtual planning and augmented reality may become valuable tools in the management of complex craniofacial bone lesions, increasing predictability and patient satisfaction while minimizing risks in revision surgeries.

Keywords: Fibrous dysplasia; Monostotic; Augmented reality; Pathology; Oral; Case report.

Resumo

A displasia fibrosa monostótica (DFM) é uma desordem esquelética benigna, não hereditária, caracterizada pela substituição do osso normal por tecido fibroso e ósseo imaturo. Embora a região craniofacial seja um local frequentemente acometido, os casos mandibulares são menos comuns e podem representar desafios clínicos e cirúrgicos significativos, especialmente quando recorrentes ou sintomáticos. Este relato de caso descreve um paciente com DFM da mandíbula, com progressão da lesão e dor neuropática persistente após cirurgia inicial. Em um segundo momento cirúrgico, foi realizado novo procedimento, com uso de ferramentas digitais avançadas, incluindo planejamento cirúrgico virtual, modelagem e impressão 3D, simulação transoperatória guiada por realidade aumentada e uso de guias de corte personalizadas. A tomografia pós-operatória confirmou alta fidelidade ao planejamento cirúrgico e melhora da simetria facial. Este caso evidencia avanços importantes na aplicação de tecnologias digitais na cirurgia bucomaxilofacial, demonstrando maior precisão, melhores resultados estéticos e preservação anatômica. É um dos poucos casos documentados de displasia fibrosa mandibular recorrente tratado com simulação cirúrgica digital e guias de corte multiplanares. Os achados sugerem que o planejamento virtual e a realidade aumentada podem se tornar ferramentas valiosas no tratamento de lesões ósseas craniofaciais complexas, aumentando a previsibilidade e a satisfação do paciente, minimizando riscos em cirurgias revisionais.

Palavras-chave: Displasia fibrosa monostótica; Realidade aumentada; Patologia oral; Relato do caso.

Introducion

Fibrous dysplasia (FD) is a non-hereditary genetic disorder characterized by the replacement of normal bone with immature osseous and fibrous tissue arranged in a disorganized pattern[1]. Clinically, it may be classified as monostotic FD (MFD) (affecting a single bone) or polyostotic FD (affecting multiple bones), with the monostotic form being the most common, accounting for approximately 70% of cases[2]. The femur, ribs, and craniofacial skeleton are the most frequently affected sites[1-3]. In the monostotic form, 27% of cases involve the skull bones, and among these, only 25% affect the mandible[4].

The diagnosis of MFD should be based on a combination of clinical findings, medical history, physical examination, radiographic features, and histopathological analysis[5]. When located in the craniofacial region, the condition is referred to as craniofacial fibrous dysplasia (CFD) and typically demonstrates slow growth, frequently being incidentally detected on routine imaging examinations, particularly in monostotic cases[3]. Non-contrast computed tomography (CT) is the imaging modality of choice to assess the characteristic radiographic features and extent of the lesion[5]. Imaging commonly reveals the classic "ground-glass" trabecular appearance, often associated with loss of the lamina dura[6].

CFD may result in significant aesthetic deformities, facial asymmetry, and, in some cases, functional impairment[3,7,8]. Treatment should be individualized and is generally indicated in cases with aesthetic or functional impact[5]. Conservative surgical management allows contouring of the dysplastic bone to restore facial symmetry and relieve symptoms without complete lesion resection[9]. Most studies recommend postponing surgical intervention until skeletal maturity is reached and the lesion has entered a quiescent phase[1,5,8].

In recent years, digital technologies such as virtual surgical planning, 3D printing, and augmented reality have emerged as promising tools to enhance surgical predictability, precision, and safety[10]. The aim of this report is to present a clinical case of monostotic fibrous dysplasia of the mandible treated with virtual surgical planning and augmented reality–guided simulation, and to discuss the benefits of this approach in the context of Oral and Maxillofacial Surgery. This case report has been reported in line with the SCARE 2025 guideline[11].

Ethical aspects

This case was approved by the Research Ethics Committee of the Hospital de Clinicals de Porto Alegre (CAAE: 95129226.7.0000.5327). The patient was informed about the risks and benefits of the procedure and of participation in the study. After reading the informed documents and having his questions clarified, the patient signed the Informed Consent Form and the Authorization for Use of Images.

Case Report

A 17-year-old male patient presented to the Oral and Maxillofacial Surgery outpatient clinic at Hospital de Clínicas de Porto Alegre reporting pain and progressive swelling on the left side of the mandible. The patient reported no previous surgical intervention, no medication use, and no allergies. Following the request for additional imaging, the patient underwent bone scintigraphy and facial computed tomography (CT), which demonstrated abnormalities; however, no involvement of other bones was identified, thus excluding polyostotic dysplasia. The patient had already passed puberty and presented with significant swelling and associated pain, with surgical intervention being indicated. Bone scintigraphy revealed increased radiotracer uptake in the mandible, indicating intense metabolic activity, without evidence of other similar areas, supporting the monostotic nature of the lesion. In addition, the absence of increased bone metabolism beyond the mandible, together with the clinical findings, suggested marked deceleration of bone growth. CT imaging showed bone thickening with areas of cortical resorption suggestive of fibrous dysplasia (FD), without involvement of dental or neural structures.

An incisional biopsy confirmed the histopathological diagnosis of fibrous dysplasia. The patient subsequently underwent corrective mandibular osteotomy through an intraoral approach, aiming at functional and aesthetic improvement, Histopathological analysis confirmed the initial diagnosis of fibrous dysplasia. Despite satisfactory immediate postoperative recovery, recurrence of pain and facial asymmetry was observed within the first postoperative year.

Multidisciplinary evaluation, in collaboration with the pain management and psychiatry teams, revealed progressive lesion growth and persistent pain with neuropathic and myofascial characteristics. The patient reported allodynia, severe daily pain with functional limitation, and significant impact on daily activities, work, sleep, and quality of life. Pharmacological treatment with amitriptyline and simple analgesics was initiated, however, adherence to the prescribed regimen was incomplete because

the patient reported excessive sedation and drowsiness, leading to treatment discontinuation.

The patient remained under follow-up, and a second surgical intervention was planned after stabilization of skeletal growth and partial symptom control. At 22 years of age, following completion of the growth period and stabilization of lesion size on clinical examination, the patient continued to report significant aesthetic concerns and persistent pain, reinforcing the indication for surgery. The new procedure aimed to correct facial asymmetry with the support of virtual surgical planning (VSP).

The objectives of VSP were to enhance procedural predictability, preserve critical anatomical structures, and optimize facial symmetry. Four surgical cutting guides were designed based on preoperative CT imaging.

The digital workflow for virtual planning, visualization in virtual reality (VR), augmented reality (AR), and mixed reality (MR), as well as computer-aided design and 3D printing of surgical guides and biomodels, followed these steps:

1) The patient underwent cone-beam computed tomography (GE Medical Systems, Revolution EVO; facial bone protocol with 0.625-mm slice thickness) for anatomical assessment.

2) Images were exported in DICOM format to the P3Dental virtual surgical planning software (P3Dmed, Porto Alegre, RS, Brazil).

3) After 3D reconstruction, planning was performed collaboratively with the surgical team.

4) The finalized plan was exported to the M3DMIX application (P3Dmed) for VR, AR, and MR visualization.

5) STL (STereoLithography) files were exported for computer-aided design of surgical guides and biomodels using CAD software (Rhinoceros 3D).

6) Files were processed in slicing software (Ultimaker Cura v5.6) and fabricated using fused deposition modeling (FDM) with polylactic acid (PLA) on a 3D printer (Ultimaker).

On the initial CT scan, areas of exostosis to be removed were delineated. The first surgical guide was designed for axial osteotomies, followed by a second guide for sagittal cuts. Postoperative CT with 3D reconstruction was superimposed onto the virtual plan, demonstrating high fidelity between the planned and achieved surgical outcomes (Figure 1).

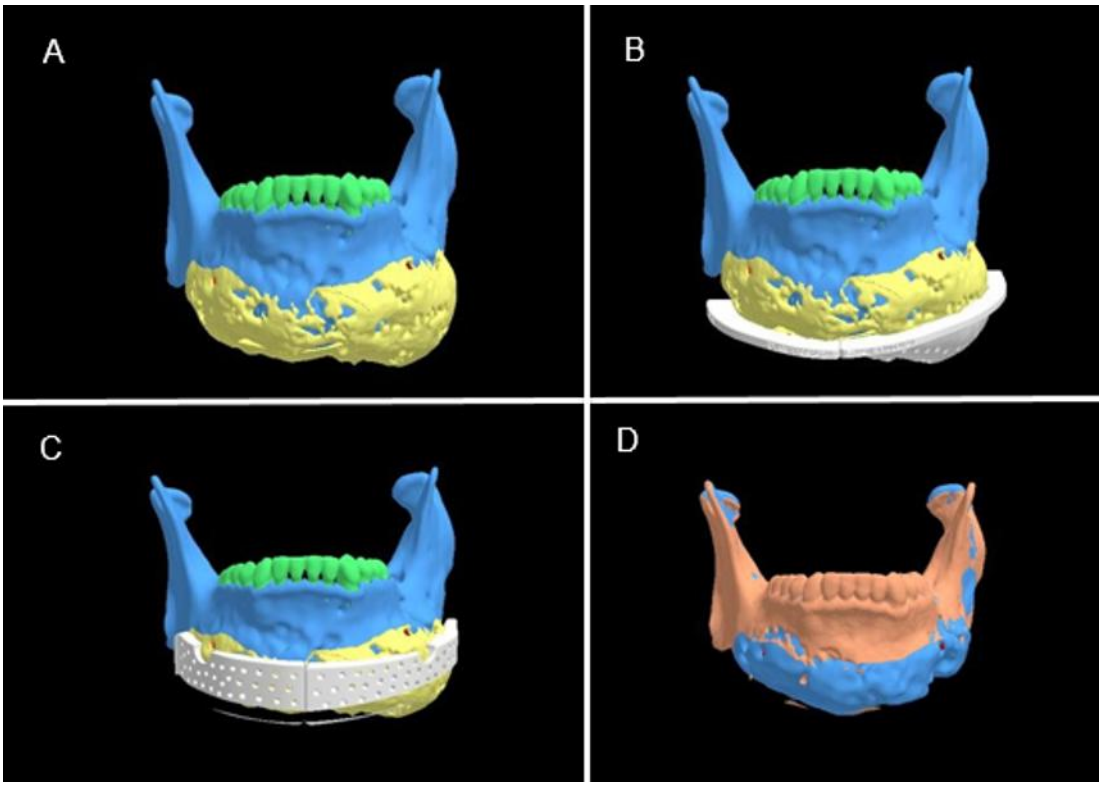

Figure 1: A) 3D reconstruction of the preoperative computed tomography scan. B) Surgical guide for axial osteotomies. C) Surgical guide for sagittal osteotomies. D) 3D reconstruction of the postoperative computed tomography scan superimposed on the virtual surgical plan.

In addition to the use of biomodels and conventional surgical guides, a surgical guide integrated with virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies was employed (Figure 2).

The QR code on the surgical guide was scanned using the M3DMIX application (Figure 3), developed by the same company responsible for the case planning (P3Dmed), enabling intraoperative visualization of the virtual surgical plan (Figure 4).

Figure 2: Biomodels and surgical guides. Surgical guide integrated with a QR code.

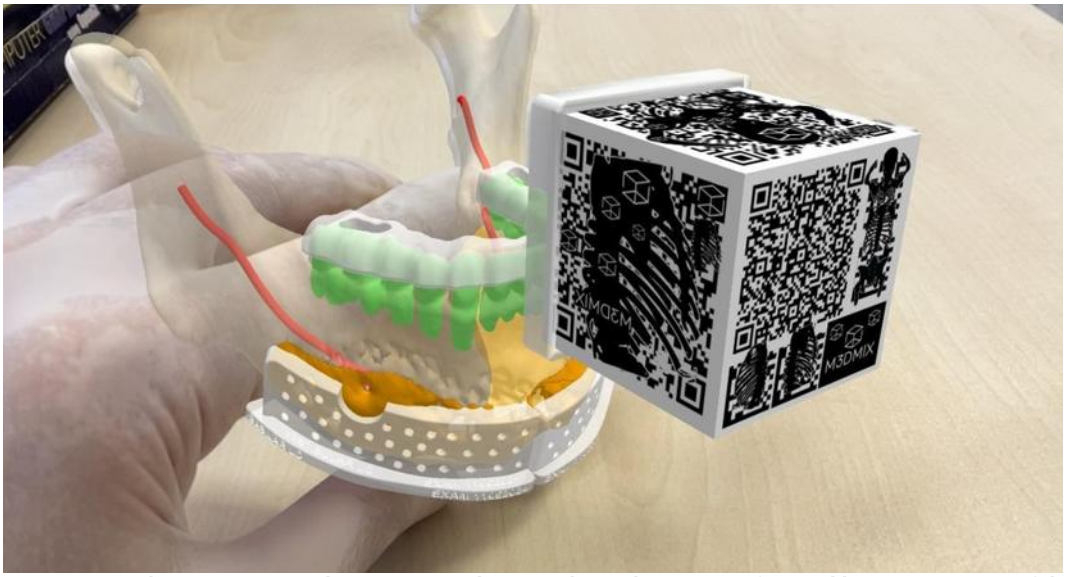

Figure 3: QR code scanning using the M3DMIX application. The application interface enables reconstruction of the mandible and surgical planning, allowing manipulation of the model, visualization of anatomical structures, and simulation of the osteotomies planned with the surgical guides.

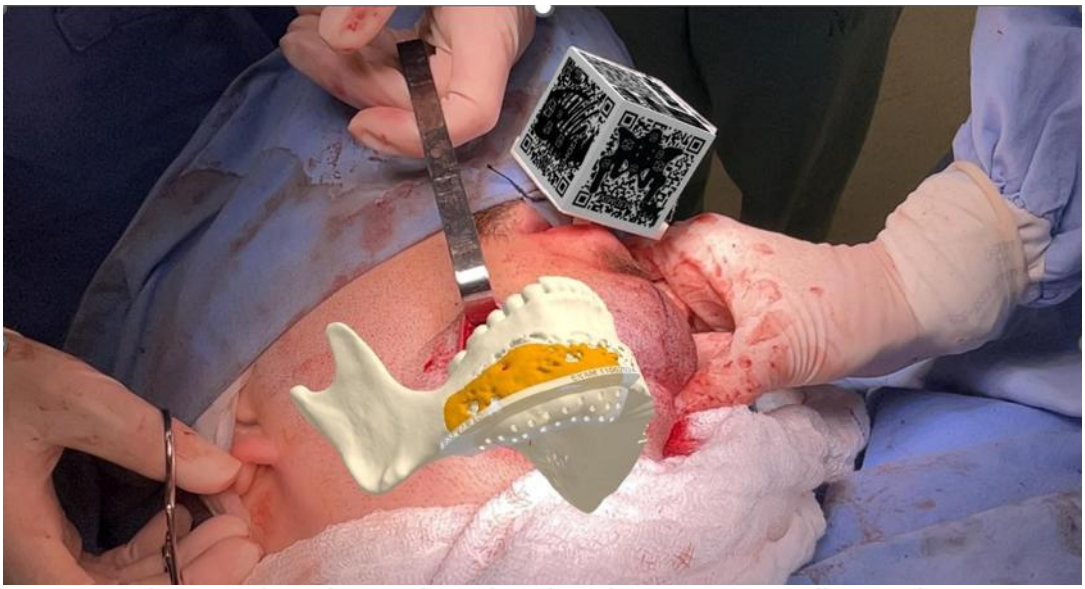

Figure 4: QR code scanning during the surgical procedure. The application screen image allows visualization and manipulation of the surgical planning directly within the operative field.

VR, AR, and MR technologies were applied through a QR code attached to the surgical guide. When scanned using a dedicated application, this code generated a reconstruction of the structure of interest overlaid onto the surgical field. In this case, the mandible with the lesion was reconstructed, and the application allowed the surgical team to manipulate the model, simulate cuts using the planned guides, and highlight anatomical structures. This enabled the surgeon to visualize, in real time and in three dimensions, both the surgical specimen and the preoperative surgical plan.

This approach allowed the integration of the three types of reality (VR, AR, and MR). Virtual reality creates fully digital, immersive 3D environments, enabling preoperative surgical training and precise surgical planning within these simulated settings. Augmented reality brings this virtual three-dimensional environment into clinical practice by overlaying digital information, such as imaging data, onto the surgical field. Finally, mixed reality proposes the integration of the digital and real worlds, allowing not only visualization but also manipulation and interaction with virtual objects, with direct clinical impact. In the present case, all three modalities were employed. VR enabled preoperative surgical planning. AR allowed scanning of the QR code and visualization of imaging data directly on the patient's face. MR enabled manipulation of both the imaging data and the preoperative plan during the surgical procedure, including simulation of osteotomies, rotations, and highlighting of relevant anatomical structures.

Virtual surgical planning enabled a safe and effective approach, providing improved control of bony margins and superior aesthetic outcomes. Preoperative and postoperative CT images demonstrated the accuracy and effectiveness of the bone contouring performed. The histopathological result was consistent with the previous findings, confirming the diagnosis of monostotic fibrous dysplasia.

At the 30-day postoperative follow-up, the patient exhibited good recovery, satisfactory healing, and reported satisfaction with facial appearance, noting improved symmetry (Figure 5) and absence of pain.

Figure 5: A: Immediate preoperative photograph. B: 30-day postoperative photograph.

At the 20-month postoperative follow-up, the patient maintained good surgical recovery, with no clinical signs of lesion growth. The patient remained satisfied with facial appearance and denied any functional impairment. No paresthesia was reported, and occasional pain in the region was noted, which was controlled with simple analgesics. This case highlights the clinical course, multidisciplinary management, and the importance of incorporating digital technologies in the surgical treatment of recurrent craniofacial fibrous dysplasia.

Discussion

Monostotic fibrous dysplasia of the mandible, although less common than in other craniofacial skeletal sites, represents a significant clinical challenge, particularly when symptomatic and recurrent. The present case highlights several features that make it relevant and, to some extent, original in the literature.

According to the literature, the monostotic form accounts for approximately 70% of FD cases and typically demonstrates slow growth with a tendency toward stabilization after puberty[9]. However, in the present case, significant lesion progression was observed even after the initial surgical intervention and completion of skeletal development, diverging from the typical clinical course described in previous studies, which report a more predictable and quiescent behavior after the growth peak[1,12].

Another noteworthy aspect was the persistent and refractory pain. Although pain is not a common finding in monostotic FD, especially in the absence of nerve compression or malignant transformation, the patient developed chronic neuropathic and myofascial pain, allodynia, and substantial functional and psychological impairment. This presentation highlights the importance and challenges of a multidisciplinary approach, including the surgical team, chronic pain specialists, and mental health professionals, for managing complex pain associated with dysplastic bone disorders.

Regarding treatment, the originality of this case lies in the surgical approach supported by advanced digital technologies, including virtual surgical planning, customized cutting guides, and superimposition of pre- and postoperative 3D models, which has rarely been described in recurrent mandibular FD. Recent studies suggest that such technologies may reduce operative time, improve aesthetic outcomes, and potentially decrease recurrence risk, findings that were supported in this case[12-16].

The main clinical and scientific contributions of this report include the longitudinal documentation of a mandibular FD case with atypical progression, postoperative recurrence, and significant chronic pain, as well as the demonstration of the effectiveness of virtual surgical planning in the reintervention of a previously operated lesion. The use of multiple CT-based cutting guides (axial and sagittal), along with postoperative 3D image superimposition confirming surgical accuracy, further emphasizes the value of

digital workflows in enhancing aesthetic and functional outcomes and patient satisfaction.

Limitations of this report include the patient's poor adherence to pharmacological pain management, which limited objective assessment of therapeutic response. Furthermore, as these are emerging technologies, the associated costs and limited access to specialized programs and software may hinder their widespread adoption. In addition, more robust studies involving these technologies are required to allow more reliable conclusions.

In summary, this report contributes to the literature by presenting an innovative and multidisciplinary approach to an uncommon clinical manifestation of monostotic fibrous dysplasia. Virtual surgical planning and customized cutting guides proved fundamental in managing a recurrent case and may serve as a reference for similar situations in oral and maxillofacial surgery practice.

Conclusion

This case report highlights the importance of an individualized and multidisciplinary approach in the management of monostotic fibrous dysplasia of the mandible, particularly in cases presenting with atypical behavior, postoperative recurrence, and persistent pain. The use of digital technologies, such as virtual surgical planning and customized cutting guides, may potentially improve procedural predictability, surgical safety, and aesthetic and functional outcomes.

This case underscores the potential of these innovations within the field of oral and maxillofacial surgery, especially in the treatment of complex and recurrent bone lesions. Nevertheless, long-term clinical follow-up and patient adherence to multidisciplinary care remain essential for adequate pain control and prevention of further lesion progression.

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