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IMPACTO DA REABILITAÇÃO FONOAUDIOLÓGICA NA RECUPERAÇÃO DAS FUNÇÕES ESTOMATOGNÁTICAS EM PACIENTES COM TRAUMA DE FACE

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IMPACTO DA REABILITAÇÃO FONOAUDIOLÓGICA NA RECUPERAÇÃO DAS FUNÇÕES ESTOMATOGNÁTICAS EM PACIENTES COM TRAUMA DE FACE

LINHA DE PESQUISA: EPIDEMIOLOGIA, ETIOPATOGENIA E REPERCUSSÃO DAS DOENÇAS DA CAVIDADE BUCAL E ESTRUTURAS ANEXAS

Orientadora: Prof.ª Dr.ª Juliana Balbinot Hilgert

Tese apresentada ao Programa de Pós-Graduação em Odontologia, nível Doutorado, da Universidade Federal do Rio Grande do Sul, como pré-requisito final para obtenção do título de doutor na área de concentração em Saúde Bucal Coletiva.

PORTO ALEGRE, SETEMBRO DE 2021

“Desde o momento em que uma pequena observação pode refutar uma afirmação, enquanto milhões de outras dificilmente conseguirão confirmá-la, a desconfirmação é mais exata que a confirmação”.

Nassim Taleb

DEDICATÓRIA

A todos os participantes do estudo que confiaram no propósito de propiciar uma reabilitação orofacial integral.

AGRADECIMENTOS

Ao Dudu, que sempre ao meu lado, apoia minhas ideias e me traz equilíbrio. Obrigada por me completar.

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RESUMO

Santos, Karoline Weber dos. **Impacto da reabilitação fonoaudiológica na recuperação das funções estomatognáticas em pacientes com trauma de face**. 2021. Tese (Doutorado em Odontologia - Saúde Bucal Coletiva) – Faculdade de Odontologia, Universidade Federal do Rio Grande do Sul, Porto Alegre.

Os traumatismos envolvendo os ossos da face podem comprometer de forma significativa as funções estomatognáticas, principalmente quando o trauma envolve a mandíbula. O objetivo desta tese foi avaliar estratégias de reabilitação das funções orais em pacientes com fraturas maxilofaciais. O primeiro artigo teve como objetivo identificar na literatura estratégias de reabilitação estomatognática utilizadas em pacientes com traumas de face por meio de uma revisão sistemática com meta-análise. A partir destes dados verificou-se uma heterogeneidade clínica entre os estudos, não sendo possível estabelecer guias terapêuticos não farmacológicos para reabilitação em traumas de face a partir da literatura reportada. O segundo artigo trata-se de um estudo de coorte a fim de avaliar a evolução funcional de pacientes com diferentes fraturas faciais ao longo do tempo. Estes dados permitiram descrever a evolução das funções orais, sendo possível identificar que indivíduos com acometimento da mandíbula apresentaram melhora funcional mais tardia em relação aos não acometidos, com impacto significativo da dor nesta evolução. O terceiro artigo teve como propósito investigar a eficácia um programa de reabilitação fonoaudiológica e benefícios associados à fotobiomodulação de baixa intensidade durante o processo de reabilitação, por meio de um ensaio clínico randomizado. Este estudo mostrou que a realização de exercícios orais associados à fotobiomodulação mostrou-se eficaz para reabilitação das funções orais, com ganho significativo no manejo da dor. A proposta de programas terapêuticos em reabilitação das funções orais ainda possui importantes limitações devido ao entendimento das necessidades populacionais, bem como conhecimento da eficácia das técnicas terapêuticas propostas. Os resultados obtidos a partir dos estudos desta tese permitiram caracterizar esta evolução e avaliar a eficácia terapêutica das técnicas

propostas, favorecendo e estimulando a proposição de maior aprofundamento na área.
Palavras-chave: Traumatismos Faciais; Mastigação; Dor Facial; Reabilitação; Terapia com Luz de Baixa Intensidade.

ABSTRACT

Santos, Karoline Weber dos. **Impact of speech therapy rehabilitation on the recovery of stomatognathic functions in patients with facial trauma.** 2021. Thesis (Doctorate in Dentistry/Dental Public Health) – Faculdade de Odontologia, Universidade Federal do Rio Grande do Sul, Porto Alegre.

Injuries involving the facial bones can significantly compromise stomatognathic functions, especially when the trauma involves the mandible. The aim of this thesis was to evaluate rehabilitation strategies for oral functions in patients with maxillofacial fractures. The first article aimed to identify in the literature stomatognathic rehabilitation strategies used in patients with facial trauma through a systematic review with meta-analysis. Based on these data, there was clinical heterogeneity between the studies, and it was not possible to establish non-pharmacological therapeutic guidelines for rehabilitation in facial trauma based on the reported literature. The second article is a cohort study to assess the functional evolution of patients with different facial fractures over time. These data allowed us to describe the evolution of oral functions, making it possible to identify that individual with mandible involvement had functional improvement later than those without, with a significant impact of pain on this evolution. The third article aimed to evaluate a speech-tharapy rehabilitation program and the benefits associated with photobiomodulation during the rehabilitation process, through a randomized clinical trial. This study showed that oral exercises associated with photobiomodulation proved to be effective for rehabilitation of oral functions, with significant gains in pain management. The proposal of therapeutic programs in the rehabilitation of oral functions still has important limitations due to the understanding of the population's needs, as well as knowledge of the effectiveness of the proposed therapeutic techniques. The results obtained from the studies of this thesis allowed to characterize this evolution and evaluate the therapeutic efficacy of the proposed techniques, favoring and stimulating the proposition of a greater deepening in the area.

Key Words: Facial Injuries; Mastication; Facial Pain; Rehabilitation; Low-Level Light Therapy.

LISTA DE ABREVIATURAS E SIGLAS

AIH	Autorização de internação hospitalar
AMIOFE	Protocolo de Avaliação Miofuncional Orofacial com Escores
ATP	Adenosina trifosfato
CID-10	Classificação Internacional de Doenças
CK	Creatina quinase
CoDAS	Communication Disorders, Audiology and Swallowing
DATASUS	Departamento de Informática do SUS
DIM	Distância interincisal máxima
EVA	Escala Visual Analógica
FBM	Fotobiomodulação de baixa intensidade
FMM	Fixação maxilomandibular
GEE	Generalized Estimating Equations
IC	Intervalo de confiança
SOD	Enzima superóxido dismutase

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1. INTRODUÇÃO

As fraturas envolvendo os ossos do crânio e da face possuem maior prevalência em adultos jovens, homens, com predomínio de acometimento em apenas um osso da face (VIANA, 2021), principalmente por acidentes automobilísticos e agressões físicas, aspectos apontados como os principais fatores de causas externas de mortalidade no Brasil. Estes traumatismos estão associados ao maior custo dia de internações hospitalares decorrentes de causas externas (SIQUEIRA, 2016).

A abordagem terapêutica para correção das fraturas pode ser cirúrgica ou conservadora, de acordo com as condições e características das lesões. Quando há indicação cirúrgica opta-se pela redução da fratura, com ou sem fixação. Além disso, a redução da fratura também pode ser associada à fixação maxilo-mandibular para maior estabilidade óssea (CHOI, 2012). Os traumatismos envolvendo a mandíbula são as lesões que mais causam impacto na funcionalidade orofacial (JENSEN, 2005). Este impacto está associado à restrição da mobilidade devido ao deslocamento dos segmentos ósseos ou pelo procedimento de intervenção necessário, como necessidade de fixação maxilomandibular (KANG, 2012; CHOI, 2012).

Os traumatismos de face podem acarretar sequelas temporárias ou permanentes das funções do sistema estomatognático de acordo com a complexidade, localização das fraturas e intervenção terapêutica proposta. A dor orofacial é a principal queixa, estando associada à restrição de movimentos, perda de força da muscular e dor mastigatória, também se observando a presença de hiperatividade muscular a fim de compensar a debilidade motora oral. (JENSEN, 2015; SILVA, 2016). As alterações aparecem predominantemente no lado de acometimento da fratura (BENAGLIA, 2014) e, quando associadas à fratura do côndilo mandibular, podem ocasionar lesões intra-articulares que dificultam a reabilitação funcional, com perda da atividade articular normal e até possível anquilose articular (DWIVEDI, 2012).

A integração entre Odontologia e Fonoaudiologia não é recente, estando fundamentada a partir da Odontopediatria, Ortopedia, Ortodontia e Cirurgia Bucomaxilofacial, principalmente no pré e pós-operatório das cirurgias

ortognáticas, considerada como um traumatismo nos ossos da face de forma planejada e direcionada. Em relação às cirurgias ortognáticas, o fonoaudiólogo atua diretamente com a equipe cirúrgica desde o momento pré-operatório com objetivo de preparar e adequar à musculatura orofacial e adaptar as funções orais para o reposicionamento ósseo (DI PAOLO, 2017). Esta intervenção precoce proporciona a redução do período de tratamento, bem como permite que o paciente compreenda o processo terapêutico e a intervenção miofuncional específica pós-operatória por vezes não seja necessária, visto conscientização e adaptação funcional consequente (KO, 2013; KO, 2015). As alterações funcionais do sistema estomatognático após intervenção de cirúrgica ortognática apresentam características similares às apresentadas em casos de traumas por causas externas (SILVA, 2016), porém a literatura é escassa na caracterização funcional destes pacientes desde a fase aguda das lesões.

Nesse sentido, faz-se necessário avaliar a implementação de ações que visam caracterizar e intervir de forma precoce nas funções do sistema estomatognático acometidas por traumas, permitindo a redução da dor e recuperação das funções orais, verificando-se o impacto de ações reabilitadoras na funcionalidade dos pacientes e possíveis fatores prognósticos.

2. REVISÃO DE LITERATURA

A Organização Mundial da Saúde descreve as estratégias de reabilitação como medidas importantes na redução da morbimortalidade, visando o melhor desfecho possível após acometimentos de saúde (OMS, 2011). Estas estratégias permitem reduzir o tempo de hospitalização e complicações clínicas, promovendo maior independência (CHANG, 2018).

Entende-se que um programa reabilitador deva ser iniciado de forma precoce e com acesso facilitado a serviços especializados, sendo capaz de identificar os problemas e necessidades de formas pontuais (KUMAR, 2017). Um programa de reabilitação deve compor técnicas físicas e estratégias de compensação das debilidades; medidas educativas de adaptação e entendimento das dificuldades apresentadas, proporcionando apoio e aconselhamento; adaptações do ambiente e das atividades cotidianas; e fornecimento de recursos tecnológicos que possam dar suporte ao processo reabilitador. (OMS, 2011).

O acesso aos serviços reabilitadores ainda é a principal dificuldade (MIRANDA, 2015). A barreira de acesso envolve limitações como a falta de planejamento estratégico e centralização dos serviços reabilitadores, bem como a falta de recursos e pessoal qualificado (OMS, 2011). Em diferentes países, a escassez de recursos destinados à reabilitação implica em poucos centros reabilitadores para atender a demanda populacional. (NEHRA, 2016; OMS, 2011).

Um maior investimento em centros reabilitadores favorece maior participação dos indivíduos na sociedade e redução de gastos em outras áreas, como previdência social e demandas de saúde, tornando o investimento em reabilitação uma boa relação custo-benefício do ponto de vista humano e social (NEHRA, 2016; OMS, 2011). Na perspectiva de atuarem como estratégia de prevenção terciária, os centros reabilitadores devem contemplar diferentes realidades sociais, culturais e que promovam acesso a fim de mitigar prejuízos funcionais, alinhando a tríade da saúde baseada em evidência. (SACKETT, 1996). Assim, avaliar a integração das estratégias de reabilitação à rede de atenção deve fazer parte do planejamento estratégico na rede de atenção ao

trauma.

Apesar de sua importância na prevenção de morbidades decorrentes dos traumas de face, as pesquisas na área de reabilitação ainda são apontadas como de difícil execução pelo seu aspecto multifatorial pela conjunção de diversas variáveis inerentes ao indivíduo, ao programa terapêutico empregado e a perdas de seguimento, por vezes trazendo poucos resultados aplicáveis em diferentes contextos (OMS, 2011). Apesar disso, a reabilitação deve ser pautada em uma conjunção de boas práticas clínicas que envolvem o conhecimento científico e clínico do profissional com intuito de aplicar a melhor estratégia possível frente às individualidades e limitações do sujeito tratado. (NEHRA, 2016; OMS, 2011).

Na área da reabilitação fonoaudiológica, o trauma de face é uma das causas de maior acometimento das funções estomatognáticas estando associado a deformidades que podem limitar ou incapacitar o indivíduo para as funções sociais (SILVA, 2016). As sequelas orofaciais, quando não tratadas, podem aumentar o tempo e número de hospitalizações necessárias, número de procedimentos, bem como a necessidade de medicamentos de uso contínuo para alívio sintomático (BENAGLIA, 2014). Além disso, podem restringir ou incapacitar o indivíduo para o trabalho, uma vez que prejudicam a capacidade de comunicação verbal e causam sintomas dolorosos persistentes durante atividades cotidianas (CARVALHO, 2010).

As demandas reabilitadoras envolvendo traumas requerem capacitação e atuação multiprofissional para que a recuperação seja efetiva (NEHRA, 2016). Neste sentido, faz-se necessária a avaliação de programas terapêuticos especializados e precoces de forma a minimizar sequelas.

2.1 Epidemiologia dos traumas de face

2.1.1 Caracterização populacional

A maior parte dos estudos na literatura nacional e internacional apresentam caracterização dos traumas maxilofaciais a partir da análise de dados observacionais retrospectivos de serviços de urgências e emergências hospitalares, bem como ambulatórios de especialidades odontológicas. O National Trauma Data Bank, maior base de dados dos Estados Unidos na

agregação de dados sobre trauma, revela que 24,9% dos incidentes registrados acometeram a região da face (NTDB, 2016). No Brasil, a partir de dados avaliados entre 2008 e 2017 baseados em dados históricos do Portal do Departamento de Informática do SUS (DATASUS) obteve-se uma incidência de traumas faciais de 14,1% sobre os traumas gerais (FIGUEIREDO, 2018), acometendo majoritariamente adultos jovens de sexo masculino (CARVALHO, 2010; MACEDO, 2008; PICAPEDRA, 2019). Brasileiro e Passeri (2016) em uma análise de dados retrospectiva de 1024 pacientes atendidos na universidade de Campinas em um ambulatório de especialidades odontológicas, identificaram 818 homens e 206 mulheres com fraturas faciais, resultando numa razão de 4:1, os quais apresentaram uma média de idade de 30 anos. Em outra amostra de 530 pacientes avaliados em uma emergência hospitalar em indivíduos com acometimentos maxilofaciais analisada por Leles e cols. (2010), verificou-se uma prevalência de 75,8% de indivíduos do sexo masculino, com pico de idade do trauma no intervalo dos 21-30 anos de idade, que somavam 171 casos (32,3%).

Siqueira e cols. em uma análise do financiamento e morbidade hospitalar referente a afecções da face e crânio (excluídas as patologias intracranianas) e de acordo com o Código Internacional de Doenças Versão 10 (CID-10), concluiu que 81,4% das Autorizações de Internação Hospitalar (AIH) eram referentes a sujeitos do sexo masculino. A identificação do grupo populacional de risco se mostra coesa entre os estudos, favorecendo a implementação de abordagens preventivas e direcionadas para contenção da morbimortalidade.

2.1.2 Causas dos traumatismos faciais

A partir da observação de dados predominantemente advindos de urgências e emergências, a caracterização dos eventos traumáticos torna-se relevante para entendimento dos eventos, os quais se mostram homogêneos globalmente. Bonavolonta e cols. (2017) em uma revisão retrospectiva dos registros de atendimento de pacientes admitidos por fraturas de face em um hospital referência em trauma em Nápoles, na Itália, demonstrou maior prevalência de lesões causadas por acidentes automobilísticos (57,1%) e

agressões (21,7%). Wulkan e cols. (2005) a partir da análise de dados de pacientes admitidos em um pronto socorro no Brasil relataram como principal fator etiológico as agressões, totalizando 48,8% das fraturas avaliadas, enquanto os acidentes de trânsito perfizeram um total de 12,9%. Dados históricos do DATASUS também corroboram que na população brasileira a ocorrência dos traumas de face está associada à acidentes automobilísticos como principal fator causal das fraturas. (FIGUEIREDO, 2018).

Em detrimento da elevada associação com acidentes de trânsito e agressões interpessoais (SIQUEIRA, 2016) foram propostas modificações nas legislações de trânsito que mencionam que a obrigatoriedade do uso de cinto de segurança, de capacete e a lei seca, as quais foram responsáveis por reduções nas incidências e severidade dos traumatismos automobilísticos (MOURA, 2017). No que tange as agressões interpessoais, são relatadas políticas visando, entre outros objetivos, promover ações de prevenção das violências e reafirmar a obrigatoriedade de notificação dos maus-tratos em crianças, mulheres e idosos (PEREIRA, 2019).

2.1.3 Morbimortalidade

Em relação aos dados de morbimortalidade, dados a respeito de tratamentos agudos e necessidade de intervenções são mais frequentemente descritos na literatura, porém os dados de evolução tardia ainda são escassos.

Em estudo brasileiro longitudinal retrospectivo que avaliou 355 pacientes com trauma de face em um serviço de cirurgia facial, apontou que em torno de 85% dos indivíduos atendidos necessitaram de hospitalização e 75% de intervenção cirúrgica (CARVALHO, 2010), destacando-se o alto custo aos serviços de saúde para tratamento desta população (MELIONE, 2008). Entre 2008 e 2017, a partir dos dados do DATASUS estimou-se uma mortalidade de 0,69% entre os indivíduos internados por fratura de crânio e face, com uma média de permanência de internação de 4,3 dias, com um custo médio de internação estimado em R$ 1769 (FIGUEIREDO, 2018).

2.1.4 Características das fraturas

Quanto às regiões anatômicas envolvidas com maior frequência nas

fraturas faciais, a mandíbula, o zigoma e os ossos nasais são os mais acometidos. Maliska (2009) em uma revisão retrospectiva de 132 pacientes que totalizavam 185 fraturas faciais demonstrou que 54,6% das fraturas envolviam a mandíbula, enquanto o zigoma representava 27,6% das fraturas. Na amostra estudada por Brasileiro e Passeri (2016) a mandíbula, o zigoma e os ossos nasais foram as regiões anatômicas mais envolvidas nas fraturas faciais, representando respectivamente 44,2%, 32,5% e 16,2% do total de fraturas. As características destas fraturas são dependentes da anatomia da região, densidade óssea, relação com musculatura e tecido cutâneo sobrejacente, bem como a força de impacto e a sua direção.

2.2 Terapêuticas nos traumas envolvendo a mandíbula

Os traumatismos que envolvem a face acometem um componente essencial para o autorreconhecimento, identidade e relacionamento social (BRASILEIRO E PASSERI, 2016; WULKAN, 2005) Os pacientes vítimas de traumatismos faciais devem ser avaliados, diagnosticados e tratados adequadamente e em momento propício a fim de se evitar ou mesmo amenizar sequelas funcionais e estéticas. As situações que resultam em alterações faciais permanentes e prejuízos funcionais constantemente acompanham sequelas psicológicas importantes (ELLIS, 1985).

A localização da fratura é o principal fator associado às sequelas funcionais, sendo a fratura de mandíbula a de maior impacto (SILVA, 2016). Discute-se que a idade, condições dentárias, localização, fragmentação e exposição da fratura e tempo para intervenção inicial são os principais aspectos que contribuem para complicações que necessitam de novas intervenções cirúrgicas (LUZ, 2013). Aponta-se também que quando há o acometimento mandibular, o acompanhamento de reabilitação funcional torna-se determinante para o sucesso terapêutico cirúrgico devido à necessidade de estabilização da oclusão dentária e controle da atividade muscular que podem interferir no posicionamento ósseo e acarretar novas intervenções cirúrgicas se não adequadamente tratadas (VEGA, 2011).

Sendo os traumas de mandíbula a maior causa de alterações funcionais, é importante salientar as terapêuticas corretivas envolvendo esta região da

face. Diversos são os componentes associados na orientação terapêutica e os casos devem ser analisados individualmente, não havendo uma orientação única de acordo com a localidade ou complexidade das fraturas (VEGA, 2011).

A indicação terapêutica pode ser cirúrgica, com ou sem fixação e/ ou bloqueio maxilomandibular, ou conservadora, mantendo-se um acompanhamento da estabilidade oclusal e queixas funcionais como referência para orientação da necessidade de intervenção futura (CHOI, 2012). Inúmeros são os fatores que contribuem para o tipo de indicação terapêutica, sendo os principais descritos a seguir.

O primeiro quesito a ser avaliado refere-se à história pregressa do paciente quanto às suas condições sociais e de saúde. Questões relacionadas ao autocuidado, doenças sistêmicas e tratamentos odontológicos prévios insatisfatórios podem ser preditores que sinalizam possíveis complicações e necessidade de reintervenções devido à maior predisposição à déficits de cicatrização e instabilidade oclusal que podem limitar a integração óssea (VEGA, 2011; LUZ, 2013). Além disso, queixas orofaciais prévias ao trauma podem ser um complicador potencial que deve ser considerado na escolha terapêutica. Principalmente a indicação da fixação maxilomandibular é um recurso que deve ser cuidadosamente avaliado havendo contraindicações em alguns casos, como doenças neurológicas envolvendo o controle motor, e aspectos potencialmente complicadores para cicatrização, como presença de doença periodontal associada ao déficit de higienização oral (CHOI, 2012; VEGA, 2011).

Outro importante aspecto a ser avaliado refere-se à estabilidade oclusal. A manutenção da oclusão dentária está condicionada a presenças dentárias, estabilidade da fratura e ajustes musculares adaptativos (KO, 2015). Aponta-se que a maior causa de insucesso cirúrgico e infecções subsequentes ocorrem quando a estabilidade da fratura não é alcançada (VEGA, 2011; JENSEN, 2006). Além disso, é importante considerar que os cuidados de higienização, adaptação da função alimentar e alterações gerais de saúde são aspectos que podem ser causadores de insucesso terapêutico, carecendo de equipe multidisciplinar especializada para atenção a esta população (CAMPOS, 2009; LUZ, 2013).

Sabe-se que o sistema estomatognático apresenta uma resposta muscular adaptativa muito sensível às condições estruturais ósseas e o posicionamento mandibular tem um papel bastante significativo neste aspecto (COUTINHO, 2009). Nos casos de intervenção óssea planejada como na cirurgia ortognática, observa-se que alguns pacientes apresentam adaptações do sistema muscular e consequentemente das funções orais de forma satisfatória, porém em alguns casos esta adaptação ocorre de forma tardia e causa grandes desconfortos pelo déficit de ajuste funcional (COUTINHO, 2009; SILVA, 2016). Nos casos de trauma, mesmo com a adaptação estrutural e funcional consequente, verifica-se uma perda na amplitude de movimentos e déficit da atividade motora, com perda da força da musculatura mastigatória, sendo necessário longo período para recuperação, com dor associada para realização das funções orais quando não há intervenção precoce (NIEZEN, 2010). Por vezes, esta adaptação não atinge a normalidade, mantendo sequelas permanentes (BITHER, 2012).

De acordo com a localização da fratura, como se observa nos casos de fratura de côndilo, esta adaptação motora pode prejudicar o adequado posicionamento ósseo e acarretar a perda da dimensão vertical e horizontal da mandíbula sendo por vezes necessária nova intervenção cirúrgica (KANG, 2012; SILVA, 2016). Discute-se que a falta de orientação terapêutica, na expectativa da recuperação funcional espontânea, possa acarretar dor orofacial permanente devido a atividades motoras compensatórias inadequadas, causando desequilíbrio da atividade motora orofacial (BITHER, 2012; NIEZEN, 2010). Além disso, a falta de reabilitação precoce pode ocasionar anquilose articular com grande impacto estrutural e funcional, sendo necessária nova intervenção cirúrgica corretiva (BENAGLIA, 2014).

A necessidade da reabilitação precoce das alterações funcionais associadas a fraturas faciais é apontada como necessária para reduzir a necessidade de novos procedimentos cirúrgicos (VEGA, 2011). Apesar disso, os programas terapêuticos são bastante escassos e pouco se discute o tempo necessário para recuperação (CÂMARA, 2014). Observa-se também que intervenção funcional ocorre por vezes de forma tardia, não permitindo reduzir o desconforto associado às fraturas de forma precoce, prolongando o tempo

para recuperação funcional. Em contrapartida, a literatura aponta práticas reabilitadoras em casos de cirurgia ortognática (COUTINHO, 2009; SILVA, 2016), os quais se assemelham muito às alterações funcionais observadas em casos de trauma, como o déficit de mobilização da mandíbula e da função mastigatória (CÂMARA, 2014).

Visando minimizar as sequelas funcionais, a AO Foundation, referência na orientação para manejo de traumas ósseos, recomenda que a reabilitação funcional deve iniciar imediatamente no pós-operatório para correção das fraturas ósseas ou, quando houver a necessidade de fixação maxilomandibular, no momento de abertura do bloqueio. Além disso, preconiza que a normalidade de abertura oral seja reestabelecida em torno de quatro semanas pós-intervenção ou abertura do bloqueio, verificando-se a precocidade das orientações reabilitadoras (EHRENFELD, 2012).

A intervenção na atividade muscular é o principal componente indicado para reabilitação funcional, com técnicas de mobilização ativa e passiva da mandíbula a fim de promover melhora da atividade motora (SILVA, 2016; KO, 2015). Diversos são os recursos terapêuticos que podem ser empregados para o restabelecimento funcional, bem como métodos auxiliares para alívio da dor e melhor conforto durante manipulação muscular, assim como o uso da fotobiomodulação de baixa intensidade (NÚÑEZ, 2006).

2.3 O que se sabe sobre fotobiomodulação?

O uso da fotobiomodulação de baixa intensidade (FBM) é reconhecido em diferentes áreas devido aos benefícios associados ao reparo cicatricial tecidual, ósseo e nervoso; alívio da dor muscular e articular; redução de edema e inflamação (SANTINONI, 2017). Na Odontologia tem sido amplamente estudado em diferentes áreas de atuação tendo sido apontado como um método seguro e confiável a fim de potencializar terapêuticas propostas e reduzir o desconforto associado aos procedimentos odontológicos (CARROLL, 2014). Sua utilização aplicada às áreas cirúrgicas, como as realizadas pela cirurgia e traumatologia bucomaxilofacial, tem sido apontada nas diferentes áreas do conhecimento como implantes dentários, extrações de terceiro molar, cirurgias de distração osteogênica e distúrbios da articulação

temporomandibular a fim de promover a cicatrização e reduzir o desconforto orofacial (JANG, 2012; FAZILAT, 2014).

Quando aplicado como objetivo do reparo ósseo, verifica-se que há melhora na densidade óssea, com ação antiinflamatória e analgésica que auxiliam na aceleração do processo cicatricial (SELLA, 2015; SANTINONI, 2017). Verifica-se que a neoformação óssea e os benefícios cicatriciais são observados nos estágios iniciais de consolidação, auxiliando na diferenciação de osteoblastos para osteócitos, com maior deposição de colágeno e centro de ossificação, favorecendo a organização celular (FAZILAT, 2014). Apesar disso, ressalta-se que o benefício cicatricial nos estágios iniciais promove a redução do desconforto orofacial proporcionando redução do tempo sintomático, permitindo melhor qualidade de vida em pacientes com acometimentos orais (SANTINONI, 2017). Em casos de traumas, verifica-se que o uso da FBM se mostra superior em promover o aumento da formação da matriz óssea e periosteal, sendo um recurso adjuvante favorável na reabilitação e estabilização das lesões (SELLA, 2015).

Na aplicação para alívio sintomático da dor em áreas articulares, uma revisão sistemática com meta-análise realizada por Jang e Lee (2012), apontou que a FBM reduziu a dor articular e parâmetros específicos de doses devem ser observados para que o tratamento seja efetivo. Em relação à articulação temporomandibular, há controvérsia entre os estudos quanto ao alívio da dor, não havendo significância e com efeito moderado (CHEN, 2015). Apesar disso, verifica-se melhora no desempenho funcional considerando-se abertura oral ativa e passiva, protrusão e lateralidade mandibular (CHANG, 2014; CHEN, 2015).

Em relação ao desempenho das funções estomatognáticas é importante salientar que a atividade da musculatura orofacial e mastigatória desempenha um papel significativo nas queixas de dor orofacial e estão associadas a restrições orais assim como as alterações intra-articulares (CHANG, 2014; CHEN, 2015). Quando aplicada ao tecido muscular, a FBM beneficia a performance muscular, aumentando significativamente o tempo para exaustão e número de repetições de contração, principalmente quando aplicada antes do exercício físico (LEAL-JUNIOR, 2015). Seus benefícios são apontados devido

ao aumento da atividade mitocondrial muscular e aceleração da resolução inflamatória. Além disso, aponta-se que o uso de laser vermelho pré-exercício diminui a presença de creatina quinase (CK) muscular, marcador que indica dano muscular, e aumento da SOD, enzima antioxidante, observados também 48h após exercício. Com o uso do laser infravermelho, também se observa redução da CK e do lactato, produto da resposta metabólica na deficiência de oxigênio, favorecendo a respiração celular (LEAL-JUNIOR, 2015). Na aplicação em trigger-points na musculatura mastigatória, também se observam benefícios funcionais específicos com aumento do limiar da dor local e da performance mastigatória (DE MORAES MAIA, 2014). Na aplicação pré-indução de fadiga da musculatura mastigatória, se observa um aumento de ATP, podendo estar relacionado à maior relaxamento muscular, aumentando a circulação local, o que acelera remoção de catabólitos da microcirculação. Sua aplicação também age nas fibras C, diminuindo a permeabilidade de membrana para Na e K, o que resulta em condução mais lenta do estímulo e é associado a um efeito anti-inflamatório (GODOY, 2018)

Aplicado em cirurgias orais, o uso da FBM também proporciona redução do edema local (ARAS, 2010; MARCHIONNI, 2010). Quando aplicada de forma extraoral em cirurgias de extração do terceiro molar, há redução do edema pós-operatório, com melhores resultados quando comparado à aplicação intraoral (ARAS, 2010). Além disso, o uso isolado de FBM sem a associação de corticosteróide é apontando como uma ferramenta eficaz na redução do edema por acelerar o metabolismo, a proliferação celular e a organização da matriz extracelular (MARCHIONNI, 2010).

Desta forma, observa-se que os benefícios cicatriciais e sintomáticos com o uso da fotobiomodulação podem ser aplicados em pacientes com traumas de face, podendo proporcionar melhora funcional precoce, devendo-se avaliar a eficácia e discutir protocolos de aplicação associado à reabilitação funcional, já descrita como determinante para efetividade do tratamento cirúrgico.

3. OBJETIVOS

3.1 OBJETIVO GERAL

- Avaliar estratégias de reabilitação das funções orofaciais em pacientes com fraturas maxilofaciais.

3.1 OBJETIVOS ESPECÍFICOS

- Identificar na literatura estudos que investigam estratégias de reabilitação estomatognática utilizadas em pacientes com traumas de face;
- Avaliar a evolução funcional de pacientes com diferentes fraturas faciais ao longo do tempo;
- Avaliar a eficácia de um programa de reabilitação fonoaudiológica e benefícios associados à fotobiomodulação de baixa intensidade durante o processo de reabilitação das fraturas de mandíbula.

4. ARTIGOS ANEXOS

4.1 ARTIGO 1 - Rehabilitation strategies in maxillofacial trauma: systematic review and meta-analysis

Publicado no periódico Oral and Maxillofacial Surgery
Santos KW, Rech RS, Wendland EMR, Hilgert JB. Rehabilitation strategies in maxillofacial trauma: systematic review and meta-analysis. Oral Maxillofac Surg. 2020 Mar;24(1):1-10. doi: 10.1007/s10006-019-00808-8.

4.2 ARTIGO 2 – Evolução das condições estomatognáticas de pacientes com fraturas maxilofaciais: um estudo de coorte prospectivo

A ser submetido para publicação.

4.3 ARTIGO 3 – Effect of oral exercises and photobiomodulation therapy in the rehabilitation of patients with mandible fractures: randomized double-blind clinical trial

Publicado no periódico Lasers in Medical Science.
Dos Santos KW, Hugo FN, da Cunha Rodrigues E, Stein AT, Hilgert JB. Effect of oral exercises and photobiomodulation therapy in the rehabilitation of patients with mandible fractures: randomized double-blind clinical trial. Lasers Med Sci. 2021 Sep 23. doi: 10.1007/s10103-021-03423-w.

4. CONSIDERAÇÕES FINAIS

A reabilitação das funções orais após fraturas maxilofaciais é um tema que carece de estudos para maior aprofundamento na área visando maior caracterização das demandas desta população, bem como estudos de eficácia e efetividade das técnicas empregadas. Neste estudo, buscou-se revisar na literatura técnicas de tratamento empregadas, descrição da população acometida quanto às demandas reabilitadoras e avaliar a eficácia terapêutica de um programa de tratamento a fim de fomentar a discussão na área. Estes aspectos tornam-se fundamentais a fim de respaldar a prática clínica e direcionar estratégias em reabilitação.

Sabe-se que propor programas reabilitadores é um desafio na prevenção de morbidades e ainda mais desafiador torna-se implementar estratégias que atinjam o público desejado, promovendo técnicas eficazes. Na literatura observou-se uma ampla gama de técnicas que favorecem a reabilitação orofacial, porém há uma importante heterogeneidade de técnicas, com limitado número de estudos de eficácia a fim de respaldar a prática clínica para proposição de guias terapêuticos. A ausência de dados embasados pode limitar a prática clínica, postergando a reabilitação, com implicações para a prática da saúde baseada em evidência. Há uma necessidade de proposição de protocolos clínicos a serem investigados a fim de promover uma reabilitação abrangente e precoce.

Além disso, apesar de difundir-se nos estudos a importância da reabilitação funcional precoce, pouco se conhece a respeito da história natural das funções orais após fraturais faciais. A partir do acompanhamento de indivíduos com fraturas faciais, foi possível caracterizar o desempenho das funções desde o evento traumático até a evolução tardia, observando-se maior demanda de indivíduos com fraturas de mandíbula no manejo de dor e evolução alimentar. O entendimento populacional, torna-se primordial para a proposição de protocolos de tratamento, visando atender demandas específicas, reforçando a integralidade do cuidado em reabilitação orofacial.

Considerando a demanda pela proposição de estratégias reabilitadoras, o ensaio clínico realizado permitiu avaliar um programa de tratamento baseado

no uso da fotobiomodulação associado a exercícios orais. O manejo da dor é um dos principais aspectos que podem limitar a evolução funcional de indivíduos com traumas faciais, principalmente devido à resposta limitante à prática de exercícios mandibulares. O uso da fotobiomodulação de baixa intensidade permitiu viabilizar de forma menos dolorosa a prática de exercícios, com menor resposta dolorosa nos indivíduos expostas, favorecendo evoluções funcionais mais precoces neste grupo. Apesar do número limitado de indivíduos tratados, a proposição do protocolo clínico mostrou-se eficaz para futuros estudos avaliarem sua condução em diferentes contextos.

A prática de reabilitação orofacial necessita um aprofundamento de estudos de suas práticas, abrangendo o conhecimento clínico e científico já existente. O estreitamento do conhecimento já utilizado por profissionais da área, experiências dos pacientes e literatura já publicada devem ser aprimorados em outros estudos a fim de favorecer a criação de protocolos terapêuticos visando a reabilitação orofacial precoce.

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REVIEW ARTICLE

Rehabilitation strategies in maxillofacial trauma: systematic review and meta-analysis

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Abstract

Purpose This study aims to investigate rehabilitation strategies to reduce trismus, pain, and edema in patients with maxillofacial trauma.

Methods An electronic search in main databases was performed, including studies published until November 2017. Clinical trials aiming to investigate therapeutic techniques to improve mandibular range of motion and to reduce pain and edema compared to other treatments were included.

Results Nine studies were included in the review with different therapy modalities: photobiomodulation, kinesiologic tape, hilotherapy, jaw exercises, and TENS. Only five studies had available data to be included in a meta-analysis. There were no differences between any of the proposed strategies and its controls to prevent trismus. Individuals treated with hilotherapy presented less pain compared to controls. Kinesiologic tape or hilotherapy reduced edema when compared to controls daily until postoperative day 3.

Conclusions There is diversity among the proposed rehabilitation techniques, and types of fractures and there are few numbers of included participants in each study. The results obtained in this review do not promote evidence to guide the use of non-drug rehabilitation techniques in patients with maxillofacial trauma after surgical intervention.

Keywords Edema · Maxillofacial injuries · Oral rehabilitation · Pain · Trismus

Introduction

Fractures involving bones of the skull and the face, mostly from car accidents and physical aggressions, with a higher prevalence in young adult males, are associated with a high cost of hospital admissions [1]. Most individuals have fractures in only one face bone, mainly the mandible. The fracture site has no direct association with the etiology of the trauma and surgical intervention is usually necessary [2, 3]. When the mandible is the affected bone, higher functional limitations are observed, especially when intermaxillary fixation that restricts active mobilization is needed [4, 5].

Trauma may cause temporary or permanent disorders in stomatognathic functions according to its complexity, fracture locations, and proposed interventions [4, 5]. Persistent orofacial pain is the main complaint associated to movement restrictions, bone and tissue asymmetries, and loss of strength of the masticatory muscles [6, 7]. Pain and edema after the trauma and the maxillofacial interventions are also consequences of tissue manipulation [8, 9]. The main dysfunction is the restriction of mandibular range of motion, especially when the mandible is fractured [3–6]. This restriction can be associated with bone misalignments that limit mobility [4, 7]; however, it is usually related to muscular tension caused by a protective containment response also associated with pain and edema [6, 7]. Considering this, therapeutic programs such as

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photobiomodulation [8], transcutaneous electrical stimulation (TENS), and active jaw mobilization [10] are described in the literature as alternatives to improve mouth functions and reduce discomfort, but the studies were not designed for patients with maxillofacial trauma.

Different therapeutic approaches are used to reestablish stomatognathic functions or to reduce discomfort after surgery. Therapeutic programs described in literature vary according to its techniques proposed, being observed a wide range of protocol interventions among the studies, even when the same treatment strategy is used [8]. Particularly in maxillofacial trauma area, few programs were described and there is no uniformity in the techniques characterization. Thus, the identification of the therapeutic efficacy of the techniques to be chosen, that is, its effects on an environment and target audience previously defined as ideal, should be carefully evaluated for proper choice in clinical application [11].

Since there is no consensus among the rehabilitation programs in literature, this study aims to verify the efficacy of different therapeutic techniques compared to each other or to the usual treatments, based on medications, to improve stomatognathic functions in patients affected by maxillofacial trauma through a systematic review of clinical trials.

Methods

The study protocol was registered in PROSPERO (CRD42017078269) and structured in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

The search strategy was defined as:

- Participants: individuals with maxillofacial trauma without restricting the location of fracture, with only one or multiple fractures. Data: first author, year of publication, country, mean age and gender in each sample group, maxillofacial fracture diagnosis and maxillofacial surgery performed.
- Interventions: therapies not based on medications that aim to reduce trismus, pain and edema after trauma or maxillofacial procedures. The treatment protocol and the follow up were registered.
- Controls: placebos of the main intervention, medications or no treatment. The treatment protocol and the follow up were registered.
- Outcomes: The main outcome was the mandibular range of motion measured by mouth opening using numerical scales. The secondary outcomes were pain, measured by numerical or visual analog scale, and edema, measured by volumetric assessment or distance between facial points.

The search was performed at PubMed/Medline, The Cochrane Central Register of Controlled Trials, EMBASE and Dentistry & Oral Sciences Source (DOSS), complemented by manual search at other sources of the health area to reduce selection bias, published until November 2017. There were no restrictions related to language or date of publication. Keywords identified at MeSH and synonyms at Google were used. Interventional prospective studies were included (clinical trials, controlled clinical trials, and randomized clinical trials), since there is few numbers of randomized clinical trials published in literature to be included. The search strategy is presented in Appendix 1.

The studies were analyzed initially by title and abstract by two independent authors (KWS and RSR), according to eligibility criteria, identifying them as "included," "excluded," or "not clear." In cases where the inclusion was not clear, a third author resolved discrepancies (JBH). Those included at this stage were read in full for final decision. The selection stages are presented in the flow diagram in Fig. 1.

The characteristics of the studies and the outcomes were extracted to a specific form designed for this study. The data were extracted was also performed by two independent authors (KWS and RSR) and with further discussion by all authors. In cases of missing data, the authors were contacted for clarification and if lack of answers, classified as incomplete in quality analysis.

The risk of bias was classified using the Cochrane Collaboration's tool [12] for assessment by two independent evaluators (KWS and RSR): "Low risk," in green; "High risk," in red; and "Unclear risk," in yellow (Fig. 2). Disagreements were discussed until consensus with other authors.

Studies that presented quantitative data were included in the meta-analysis. The estimated effect of a treatment between groups was expressed as mean difference, when the use of the same measurement scale was used between studies, or standardized mean difference, when the studies measured the same outcome but with different methods, with a 95% confidence interval. Heterogeneity was calculated using the chi-squared test (χ^2), considered significant at $p < 0.10$. The quantifying inconsistency was expressed by I^2, considering values greater than 50% as substantial heterogeneity. A fixed-effects model was used for calculation of summary estimates and their 95% confidence interval, unless there was significant heterogeneity, which was analyzed by a random-effects statistical model. Sensitivity analysis was performed on the results with high heterogeneity to assess the robustness of the data, excluding studies with high risk of bias and analyzing the effect on the overall estimates. Subgroup analysis was performed to compare different types of interventions keeping the same heterogeneity analysis previously described.

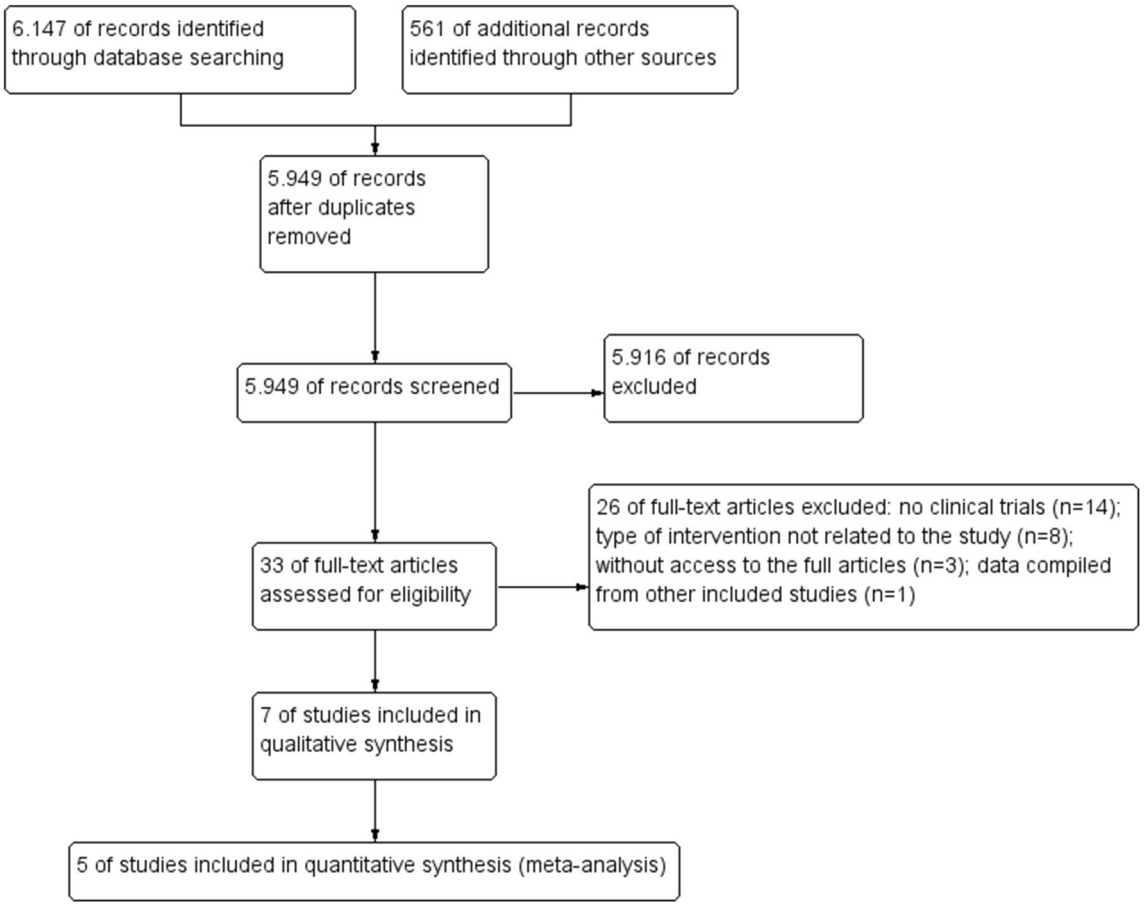

Fig. 1 Flow diagram

Meta-analysis was performed on software RevMan v5.3 and agreement between evaluators on Spss v.22.

Results

After removing duplicates, 5949 studies were screened. Of these, 33 articles were assessed for eligibility. After screening the full text, seven studies were included in qualitative synthesis [13–19] and five at quantitative analysis [14–17, 19] (Fig. 1). Inter-rater agreement of the search strategies, article inclusion, and data extraction were assessed using the kappa coefficient, with the following results, respectively: 0.95, 1, and 0.98, demonstrating a great agreement between the authors.

The characteristics of included studies are presented in Table 1. Six studies were performed with two [13–17, 19] groups without crossover treatment and only one with one group [18]. The patients had fractures in the middle [14, 15] or lower third of the face [13, 16, 17, 19] or multiple maxillofacial fractures [18]. Men were the most affected in all studies with age around 40 years old. Regarding maxillofacial intervention, open reduction and internal fixation were performed in six studies [13–18], being in one of them associated with intermaxillary fixation for 1 week after surgery, without mentioning if rigid or elastic [18], and one study performed only intermaxillary fixation with elastics for 6 weeks [19]. Both studies that used intermaxillary fixation did not differentiate the procedure as intraoperative or postoperative.

All included studied began the rehabilitation program immediately after surgery. The studies had different amounts of therapeutic sessions ranging from only one to weekly until 12 weeks after surgical procedure. Five studies used the same medicine therapy for both studied groups [13–17]. Concerning the rehabilitation techniques, one study described a photobiomodulation therapy using laser compared to a placebo treatment [13]. Two studies used kinesiologic tape associated with regular medicine treatment and ice packing compared to individuals without tape [14, 16]. Two studies compared different methods of cooling (hilotherapy X ice packing) [15, 17]. One study investigated oral exercises as the main intervention without a control group [18] and one study investigated TENS compared to treatment with medicines [19].

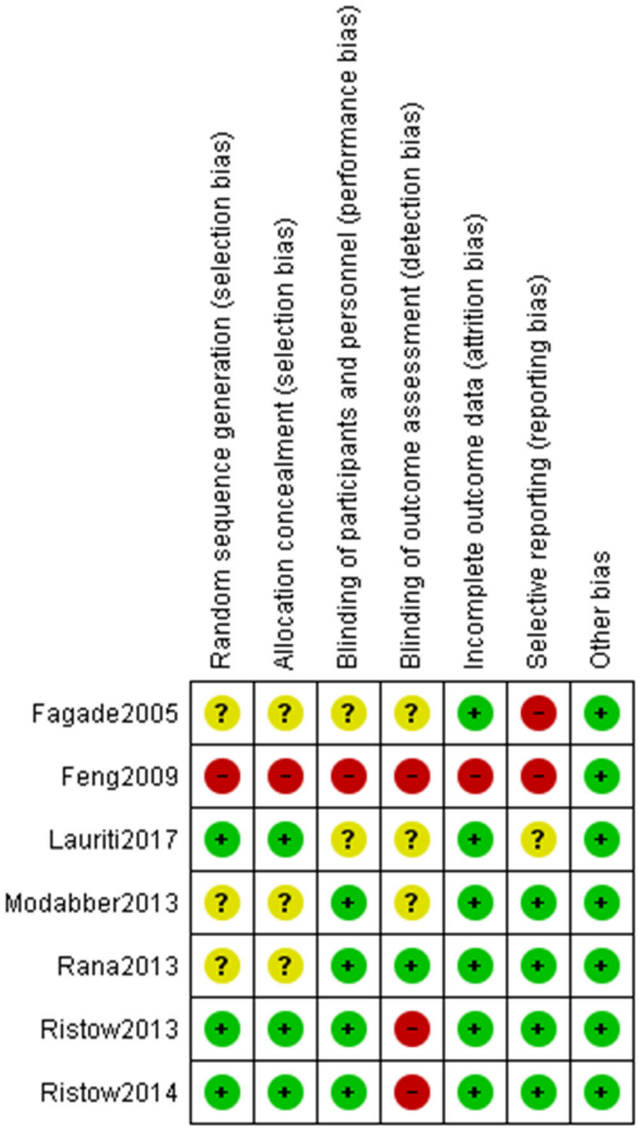

Fig. 2 Risk of bias in included studies

Risk of bias in included studies

Allocation

Most of the studies presented a high or unclear risk [15, 17–19]. The authors did not perform randomization [18] or described subjects as randomly assigned but with insufficient information to determine allocation concealment [15, 17, 19].

Blinding

Four studies presented a low risk of blinding of participants and personnel [13–15, 17]. Some proposed interventions did not allow blinding of the participants due to the nature of the treatment, but it is still not a justifiable aspect to consider a low bias, most of the studies were thus classified because it is understood that the investigated outcomes are objective measures that do not depend on the individual's response that could generate bias, on the contrary if the examiner's blinding was not performed. In this case, only one study was considered low risk. Those that received a high or unclear risk did not blind the participants and not assure a blinded evaluation [14, 16, 18] or did not clearly specify blinding [13, 15, 19].

Incomplete outcome data

Most of the studies had a low-risk classification due to the well-presented data about recruitment and follow-up [13, 15–17, 19]. One study had poor methodological description without enough information to be classified as low risk [18], and one did not specify loss of follow-up, with insufficient information concerning the sample size in results to evaluate missing data [14].

Selective reporting

Most studies presented enough information and outcome descriptions [13–17] that allow reproducibility. Two studies were classified as high risk [18, 19] due to low quality of description in the methodology and the results session. The procedures were poorly described, not being possible to reproduce the study or the results were biased.

Other potential sources of bias

We consider that the main aspects about bias were adequately evaluated in the other sessions, and no other aspects that could generate bias were identified.

Effects of interventions

Although the location of the fracture is a factor that influences the analyzed outcomes and was considered an important variable for data stratification in the protocol of this systematic review, it was not possible to be performed due to the few number of articles in the literature. Nevertheless, a sensitivity analysis was performed removing studies with different types of fracture and no difference was observed in results of the meta-analysis.

Considering that we included studies with different types of fractures and few number of included studies, we decided not to perform an indirect meta-analysis between different rehabilitation strategies because those results could be biased and not bring adequate information. Nevertheless, it was decided to compare the use of different techniques versus the use of conventional practice in order to verify the effect of using any additional technique to clinical practice, regardless of the treatment method chosen. Thus, the studies were grouped according to days after intervention in each outcome in order to investigate the effects in an overall way for patients with

Table 1 Characteristics of included studies

First author Year Country	Study design	Population *N* (mean age (years))	Gender (F/M)	Diagnosis	Maxilofacial surgery	Intervention group	Control group	Treatment protocol	Evaluation follow-up
Lauriti 2017 Brazil	Randomized control trial	I: 6 C: 6 (34.5 ± 7)	12 (M)	Mandibular fractures	Open reduction and internal fixation	Laser therapy + antibiotics and anti-inflammatory steroids	Laser sham + antibiotics and anti-inflammatory steroids	- 3 sections per week beginning immediately after surgery. 15 sections: 0, 7, 14, 30 and 60 days after surgery. - Drug therapy not described	- Mouth opening, pain and edema: 7, 14, 21, 30, and 60 days after surgery - Any loss of follow-up
Ristow 2014 Germany	Randomized clinical trial	30 (41.4 ± 18.5)	14/16	Zygomatic-orbital fracture and zygomatic maxillary fracture involving orbital floor	Open reduction and internal fixation	Kinesiologic tape + analgesic drug therapy + ice pack application 6 h after surgery (alternating each 30 min)	Analgesic drug therapy + ice pack application 6 h after surgery (alternating each 30 min)	- Kinesiologic tape left at least 5 days (edges were trimmed if tape lifted before removal.) - Drug therapy for 3 days in both groups	- Mouth opening, pain and edema: preoperative, after operation, 1, 2, 3, and 7 postoperative days - Loss of follow-up: not mentioned
Modabber 2013 Germany	Randomized control trial	I: 21 (36.5 ± 16.1) C: 21 (35.6 ± 21.9)	I: 4/17 C:3/18	Unilateral zygomatic bone fractures	Open reduction and internal fixation	Hilotherapy + analgesic drug therapy	Conventional cooling + analgesic drug therapy	- Both cooling methods were initiated after surgery until postoperative day 3 continuously for 12 h daily. - Drug therapy for 3 days in both groups	- Edema: 1, 2, 3, 7, and 28 postoperative days. The 90 postoperative day ware considered the reference of patient. - Pain: preoperative, 1, 2, and 7 postoperative days - Any loss of follow-up
Ristow 2013 Germany	Randomized control trial	I: 13 (43.8 ± 20.7) C: 13 (42.5 ± 16.7)	I: 7/6 C: 4/9	Mandibular fractures	Open reduction and internal fixation	Kinesiologic tape + analgesic drug therapy + ice pack application 6 hours after surgery (alternating each 30min)	Analgesic drug therapy + ice pack application 6 h after surgery (alternating each 30 min)	- Kinesiologic tape left at least 5 days (edges were trimmed if tape lifted before removal.) - Drug therapy for 3 days in both groups	- Mouth opening, pain and edema: preoperative, after operation, 1, 2, 3, and 7 postoperative days - Any loss of follow-up
Rana 2013 Germany	Randomized control trial	I: 16 (27.1 ± 11.9) C: 16 (33.4 ± 13.3)	I: 3/13 C: 2/14	Bilateral mandibular fractures	Open reduction and internal fixation	Hilotherapy + analgesic drug therapy	Conventional cooling + analgesic drug therapy	- Both cooling methods were initiated after surgery until postoperative day 3 continuously for 12 h daily. - Drug therapy for 3 days in both groups	- Mouth opening: before and directly after surgery, 2, 10, 28, and 90 days after surgery - Pain: preoperative, 1, 2, and 10 postoperative days - Edema: 1, 2, 3, 10, and 28 postoperative days. The

Table 1 (continued)

First author Year Country	Study design	Population *N* (mean age (years))	Gender (F/M)	Diagnosis	Maxilofacial surgery	Intervention group	Control group	Treatment protocol	Evaluation follow-up
									90 postoperative day ware considered the reference of patient - Any loss of follow-up
Feng 2009 China	Clinical trial	117 (range between 19 and 62)	31/86	Single or multiple jaw fractures, with or without fracture of the zygoma and zygomatic arch but no deossification	Open reduction and internal fixation + Intermaxillary fixation with elastics for 1 week	Jaw exercises	No controls	Weekly, until 12 weeks after surgery	- Mouth opening: 1, 4, 8, and 12 postoperative weeks - Any loss of follow-up
Fagade 2005 Nigeria	Randomized control trial	I: 10 (34,5) C: 10 (36,2)	I: 4/6 C: 6/4	Simple and unilateral mandibular fracture	Intermaxillary fixation for 6 weeks	Jaw exercises with wooden spatula + TENS + jaw exercises again	Jaw exercises with wooden spatula + analgesic treatment (1000 mg paracetamol) + jaw exercises again	One session after removal of the Intermaxillary fixation - Did the exercise, applied TENS for 30 minutes and then repeat the exercises - Did the exercise, took medication and wait 30 min to repeat the exercises	- Mouth opening: the maximum number of wooden spatula that the patient could tolerate and the inter-incisal distance were measured before and after each treatment

F female, *M* male, *I* intervention group, *C* control group, *TENS* transcutaneous electrical nerve stimulation

maxillofacial fractures. The effects of intervention presented different results according to the outcome evaluated.

Trismus

Four studies compared the mandibular range of motion by mouth opening with five different modalities of treatment: laser therapy [13], kinesiologic tape [14, 16], hilotherapy [17], oral exercises [18], and TENS [19]. All studies presented results with improvement in mandibular range of motion after interventions, but with no difference between the study groups in all proposed treatments at any time.

Pain

Three modalities of treatment were proposed to reduce pain: laser therapy [13], kinesiologic tape [14, 16] and hilotherapy [15, 17]. No difference between the investigated groups was found using laser therapy. The patients who received hilotherapy presented better results compared to the usual treatment in 1 and 2 days of intervention when the mandible [17] or the zygomatic bone [15] was affected, without difference between study groups using kinesiologic tape (Fig. 3).

Edema

Five articles measured edema in different times of investigation using laser therapy [13], hilotherapy [15, 17], and kinesiologic tape [14, 16] as experimental group. Using laser therapy [13], no difference was found between the study groups.

After 1 day of intervention [14–17], individuals treated as the experimental group presented statistical reduced edema, compared to controls, using hilotherapy [15, 17] and kinesiologic tape [14]. Considering the measures 2 and 3 days after intervention, there was a statistical difference between experimental and control groups, but with high heterogeneity among studies ($I^2 > 50\%$), even when a random effect model was applied. Performing a sensitivity analysis, considering only studies with low risk of bias in blinding [15–17], individuals treated as experimental group also presented statistical reduced edema compared to controls and low heterogeneity between studies after 2 days after intervention. The final sensitivity analysis is presented in Fig. 4.

Discussion

The results of this systematic review present different strategies of rehabilitation after surgical procedures in patients with maxillofacial trauma without guidance regarding the best treatment option. The orientation of orofacial rehabilitation after trauma, especially with mandibular involvement, recommends the use of exercises after surgical interventions to restore mouth opening and mandibular functionalities [4–6], which was observed to be little used, being identified only in two included studies [18, 19]. The association of complementary therapeutic methods with interventions conventionally used, fundamentally based on medicines, may favor recovery of pain and edema and provide comfort to the patient at the postoperative moment, as observed in the experimental group of the presented studies in different types of bones fractures.

The presence of mandibular trismus is one of the main disturbances observed in patients with facial trauma [6, 7]. Rehabilitation techniques should be performed to minimize the range of motion deficit after maxillofacial intervention and to restore normal amplitude in order to improve stomatognathic functions [4, 5]. We identified studies that used laser therapy [13], kinesiologic tape [14, 16], hilotherapy [17] and TENS [19], but those interventions did not present better results compared to controls. The use of laser therapy has been widely studied in the maxillofacial area, with favorable results for the management of trismus, since it increases the ATP synthesis and, consequently, the muscle activity

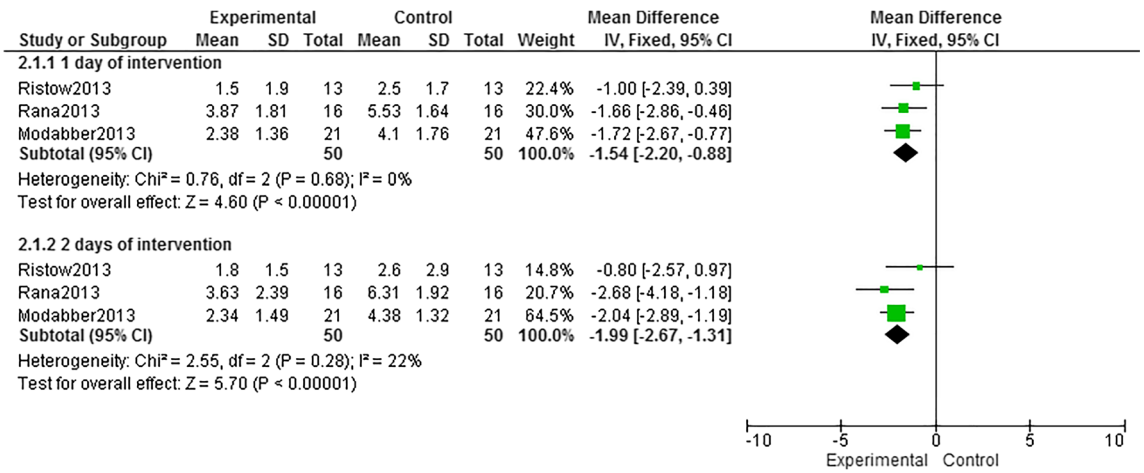

Fig. 3 Meta-analysis of outcome pain

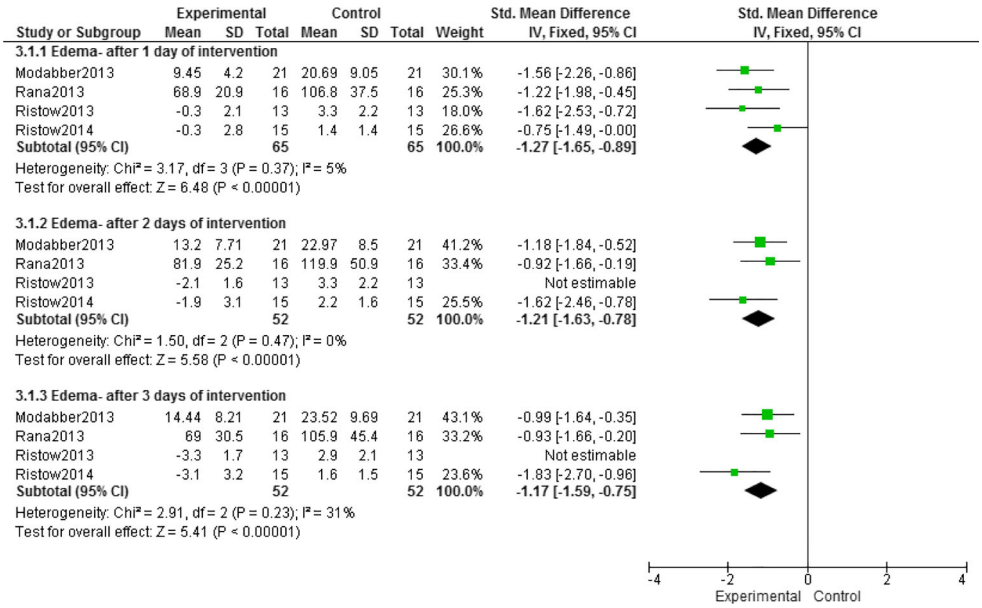

Fig. 4 Meta-analysis of outcome edema. Legend: Risdow 2013 was removed from the final model after sensitivity analysis

Legend: Risdow 2013 was removed from the final model after sensitivity analysis.

[20–22]. The authors of the included study identified improvement of mouth opening earlier in the treated group [13]; however, due to the small number of participants included, this difference did not appear to be significant. The strategies based on kinesiologic tape and hilotherapy act on the reduction of local inflammatory response [14, 16, 17], but do not act directly on the muscular performance in order to promote mobility improvement. The only study that used oral exercises in both groups, as recommended by the literature, presented good improvement for the entire sample independently of the main strategy to reduce pain.

As mentioned before, the use of oral exercises promotes the mobilization of the masticatory muscles, reducing the presence of trismus [7]. This technique has a high level of evidence that supports its use for the management of trismus and painful response especially in patients with chronic orofacial pain [22, 23], but few studies have evaluated its applicability in the treatment of maxillofacial trauma. Its indication is found in many maxillofacial surgery guidelines [4–6], but there is a lack of protocols in literature to guide practice, and the results in this review are insufficient to provide new orientation about that.

Postoperative pain is also a factor that may limit mouth opening, leading to increased use of medications for symptomatic relief, and may become persistent if untreated [21,23]. Two rehabilitation techniques were identified, kinesiologic tape and hilotherapy, but only the latter favored symptomatic relief when compared to controls [15–17]. The benefits of stimulating local circulation through constant cooling favors pain relief and can contribute to reduce medicine intake in different types of fractures, promoting patient comfort even though it does not favor the reestablishment of mouth opening [15, 17].

The presence of postoperative edema results from the surgical manipulation of bone fragments and tissues and also the surgical incision required for the procedure [21]. Its treatment is usually performed with medicines [21, 23], as presented in all studies included in this review. Despite this, the use of antiedematous drugs is restricted for some patients, who may benefit from complementary techniques if effective.

The use of photobiomodulation has been pointed out as a good tool to control postoperative edema in the maxillofacial area [21, 24], but the only study that used it in trauma did not find differences between its groups. The use of hilotherapy and kinesiologic tape led to less postoperative edema in individuals in the experimental groups, with no difference between therapeutic techniques. After a sensitivity analysis, individuals exposed to the complementary rehabilitation strategies presented less edema compared to individuals treated only with medicines until three postoperative days. Despite the differences in the complication rate of the different treatment modalities that influence the results of the present systematic review, these findings could help to guide the use of non-drug therapies after surgery in order to control edema.

We found few non-surgical rehabilitation studies for inclusion in this review, meaning that the evidence in this area is still limited. There is diversity among the proposed rehabilitation techniques and types of fractures, and there are few included participants in each study, which may compromise the clinical significance of the results, making it not possible to homogenize the indications and contraindications of those strategies. Besides, it is necessary that further researches using oral exercises be performed in order to clarify its role since it is usually indicated after maxillofacial interventions. The methodological quality of the studies also limits its reproducibility,

making evidence of rehabilitation strategies still insufficient to guide protocols.

It is important to emphasize the diversity of population included in this review. Different types of trauma can affect the assessed outcomes in different ways and should be analyzed separately, but there are few studies to allow this evaluation. Despite this, this review is relevant to present interventions not based on medicines that may contribute in the maxillofacial rehabilitation process and the importance of future researches in the area. For future studies, it is important that further efficacy studies be conducted to identify the effects of the techniques used, as there is a scarcity of evidence to guide clinical practice. Besides that, the bias should be adequately controlled based on the thorough elaboration of clinical trial protocols based on CONSORT. Other outcomes, as bite force and improvement in food texture, should be analyzed in follow-up in order to provide better data regarding long-term stomatognathic functionality.

Conclusion

The results obtained in this review are still insufficient to promote evidence that allow a clear definition of how to use non-drug rehabilitation techniques in patients with maxillofacial trauma since there are few studies with reasonable methodological quality, with a low quality of evidence according to GRADE assessment. It is important that future randomized clinical trials with appropriate methodological propositions be performed in order to provide evidence in the area before definitive conclusions can be provided.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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ORIGINAL ARTICLE

Effect of oral exercises and photobiomodulation therapy in the rehabilitation of patients with mandible fractures: randomized double-blind clinical trial

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Abstract

Mandible fractures compromise stomatognathic functions, requiring rehabilitation. Evaluate the effectiveness of photobiomodulation (PBM) associated with oral exercises for rehabilitation of patients with mandible fractures. In this randomized clinical trial, we compared PBM with PBM sham in 14 adults with mandibular fractures who underwent surgical intervention. The sessions were performed 24 h and 48 h after surgical procedure, and weekly for 4 weeks after hospital discharge. Both groups performed oral exercises after each PBM session. Restriction of food consistencies, mandibular mobility, pain, and facial sensitivity measured before and after the surgical procedure were the outcomes evaluated, one and 3 months after surgery. Maximum interincisal distances (MID), exercise pain, and restriction of food consistencies were also evaluated during each week of intervention. Both groups showed normal MID (> 35 mm) and food consistencies consumed 1 month after the surgical procedure, with no significant differences between them. Individuals in the PBM group had less pain response to exercise during all the weeks of intervention than the sham group ($p < 0.05$). The patients presented a reduction in the painful response in MID and mandibular laterality movements 1 month after surgery compared to the preoperative period. In contrast, there was an improvement in laterality in the sham group only 3 months postoperatively and persistent pain in MID. There was no significant difference in facial sensitivity within and between groups during follow-up. The performance of oral exercises associated with PBM effectively facilitated the early rehabilitation of oral functions, with significant gains in pain management.

Keywords Mandibular fractures · Maxillofacial injuries · Physical therapy modalities · Exercise therapy · Laser therapy · Low-level light therapy

Introduction

Mandible fractures are the most common type of maxillofacial fracture seen in emergency services [1]. Stomatognathic functions may be compromised according to the fracture's location and complexity due to persistent orofacial pain, bone misalignment, and protective restraint response, characterized by the stiffness of the masticatory muscles [1–3]. Mandibular misalignment restricts the movement range and alters the biomechanical dynamics of force distribution, generating tension and compression zones, especially in the body, angle, and mandibular branch, compromising oral functions [1, 2, 4, 5].

The insertion of different rehabilitation techniques in the therapeutic plan for managing mandibular trauma contributes to preventing and controlling comorbidities arising

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from injury and surgical intervention [2, 6]. Performing oral exercises provides the maintenance of intraoral movements, enabling the movement of the phono-articulatory organs used for chewing, swallowing, and speaking [6, 7]. The active mobilization of the mandible in traumatic events favors the prevention of a protective containment response, reducing muscle contracture and favoring the maintenance of the motor fiber elasticity [6]. Guidelines for maxillofacial surgery indicate the use of oral exercises after maxillofacial procedures; however, therapeutic protocols are still scarce in the literature [5, 7], with a low number of clinical trials observed in the previous meta-analysis supporting the recommendation and without investigating the intervention's benefits immediately after the surgical event [6].

Photobiomodulation therapy (PBM) is a non-invasive and non-pharmacological therapy that uses a light source for therapeutic purposes and has demonstrated beneficial effects in oral rehabilitation [8–10]. There is evidence of gain in bite force in patients suffering from mandibular fractures, resulting from phototherapy's anti-swelling effect, with higher drainage of the plasma and lactate from the inflamed region, which favors muscle function [3]. Its use in post-surgical oral interventions generates analgesic and anti-inflammatory effects, stimulating tissue healing [11, 12], and favoring the growth and regeneration of undamaged collateral nerve fibers [13]. However, photobiomodulation therapy effects in the population affected by facial trauma are still little studied, showing variability in therapeutic protocols [6].

Considering the above, it is hypothesized that the use of oral exercise techniques associated with low-intensity photobiomodulation could favor the early functional rehabilitation of patients affected by mandibular trauma. Thus, this study aims to verify PBM's superiority compared to sham, both associated with the performance of oral exercises, in the rehabilitation of patients with mandibular fractures.

Methodology

The ethics committee approved the Project of the Conceição Hospital Group, registered under ReBEC (7671), and reported according to the directives of the CONSORT. [14]

Participants

The sample consisted of individuals over 18 years of age, able to respond voluntarily to the research protocol, admitted from the hospital emergency, and approached up to 24 h after arriving at a trauma reference hospital due to a mandible fracture. The fractures were diagnosed by computed tomography, excluding those with fractures involving other facial bones and with a history of trauma for more than 7 days. The individuals identified as eligible were invited to participate in the study and signed the free and informed consent form after presenting the objectives and clarifying doubts.

The sample size was calculated considering an 8% prevalence of functional complaints among individuals with mandibular fracture submitted to rigid internal fixation [15]. Therefore, 16 individuals (8 in each study group) would be necessary to obtain a statistic power of 80% with a significance of 5%.

Baseline

The individuals completed a questionnaire to describe the sociodemographic and behavioral variables (sex, age, ethnicity, education, monthly family income, alcohol consumption, smoking, and cause of trauma) to characterize the sample. Furthermore, the fracture's characteristics (affected side, number of lines, location, and typology) were described using radiographic data.

The outcome assessment protocol was conducted by a researcher with expertise and extensive experience in stomatognathic rehabilitation and not involved in the proposed treatment protocol, which consisted of the following variables: (1) conditions of the stomatognathic system for classifying food intake consistency; (2) mandibular mobility; (3) pain; and (4) facial sensitivity.

1) The stomatognathic system was assessed to describe the appearance and posture, mobility, and stomatognathic functions through a validated protocol [16]. The consistency of food intake to be maintained [17] was recommended based on the functional conditions for mastication and swallowing the bolus and performing oral movements comfortably by the patient, described for the study with or without food intake restriction according to masticatory demand.
2) The range of mouth opening movement (from the maximum interincisal distance), mandibular protrusion, and bilateral laterality were measured to characterize mandibular mobility using a digital caliper, recorded in millimeters.
3) Complaints at rest were evaluated; spontaneous mouth opening; and palpation of the fracture traces were assessed to measure the level of pain using a visual analog scale (VAS) with a score from zero to 10.
4) For facial sensitivity, a complaint of altered sensitivity was recorded, classified as with or without alteration. A sensitivity test was also performed bilaterally on the lower alveolar nerve using the Semmes–Weinstein Monofilament Test [18], which graded the sensitive response in six levels, one normal and the others at different levels of alteration, according to the thickness of different monofilaments through touch. For this study,

the data were grouped and classified with or without altered sensitivity.

A daily program of guidelines was started after the first assessment, maintained until the surgical intervention, covering the following aspects:

1. Anatomo-physiological orientations regarding the structures involved in the fracture site and possible functional impact;
2. Orientation of cervical mobilization and raising from the bed to reduce muscular contractures of the shoulder girdle and neck, in addition to mandibular positioning during rest and sleep to reduce pressure points on the fracture regions;
3. Orientation and monitoring of oral hygiene;
4. Stimulation and care orientation for mandibular mobilization (control of mouth opening, mandibular laterality, and speech) to preserve oral functions;

The patients underwent the intervention according to the surgical team's scheduling, but the indicated technique and medication management were performed without standardization due to the study, respecting technical and individual criteria, as recommended by the Declaration of Helsinki.

Randomization and allocation

Individuals who underwent a surgical procedure and did not undergo maxillomandibular block were considered eligible for randomization. All allocated individuals were exposed to an oral exercise program by a researcher previously trained and not involved in the PBM sessions and randomized into PBM and PBM sham. A computer program consecutively generated the allocation sequence by a researcher not involved in the study in the parallel proportion of 1:1. The allocation sequence of each participant was maintained in individual opaque, non-translucent envelopes, closed until the moment of the first intervention session with PBM. The envelopes were identified externally by a number also assigned to the patient to allocate in the study, revealing the allocation only to the researcher who performed the PBM session. This resource was maintained throughout the research to blind the evaluator. The patients also did not know the participating group, and their designation was revealed only after statistical analysis, identified in the databases only by numbers.

Therapeutic procedures

After the procedure, the individuals remained hospitalized after the surgical intervention and two PBM sessions were performed, 24 h and 48 h. The laser equipment used was therapy—EC (DMC, Brazil) with infrared irradiation, a wavelength of 808 ± 10 nm, power of 100 mW ± 20%, and an area of 1 cm^2 (in CW mode). Extra-oral laser applications were conducted along the fracture traces using a beam by direct contact with the skin, with equidistance between the $1 cm^2$ points. The number of applications varied according to the number of fracture traces, irradiation of up to three points per line, and an application time per point of 80 s (dose = 0.1 W × 80 s = 8 J), fluency of 8 J/cm^2 per point [19]. The beam was also applied bilaterally to the pre-auricular condyle center, with application time per point of 40 s (dose = 0.1 W × 40 s = 4 J), fluency of 4 J/cm^2 to maintain joint lubrication [20]. Additionally, the beam was applied bilaterally at three points on the masseter muscle (superior, medial, and inferior) for 120 s at each point (dose = 0.1 W × 120 s = 12 J), fluency = 12 J/cm^2 [21]. Figure 1 illustrates the irradiation sites.

The researcher responsible for the protocol performed the asepsis of the skin with alcohol, using protection goggles for him/herself and the patient provided by the manufacturer of the laser equipment. The researcher positioned the laser in the first application site and followed the sequence point irradiation beginning with the fracture traces, masseter, and temporomandibular joints, respectively. The application sequence was maintained for both study groups, differing only in laser activation. For patients in the sham group, the researcher kept the laser in position and modified the point every 10 s, triggering a previously recorded sound signal to maintain the same application scenario as the experimental group. After the second PBM session, the outcome assessment protocol was performed again to analyze the therapeutic evolution immediately before hospital discharge.

One week after the hospital discharge, the first outpatient visit was performed, with appointments scheduled weekly for 4 weeks. Each session began by applying the PBM protocol, maintaining the same protocol after surgical intervention. Individuals from both groups underwent an oral exercise protocol after the application, with the therapist blinding the PBM protocol, consisting of:

1. Anatomo-physiological orientation regarding the structures involved in the fracture site and possible impact on chewing, swallowing, and speaking, demonstrating the patient's exams and anatomical figures;
2. Stretching the scapular and cervical region [22];
3. Massaging and stretching the masticatory muscles [23];
4. Performing 12 sets of active-assisted movement of the mandible, with rests of 60 s every three sets, keeping the mouth open for 10 s with subsequent slow closing.
5. Aid to keep the mouth open and gain range of motion with the therapist's fingers' support in the molar region.

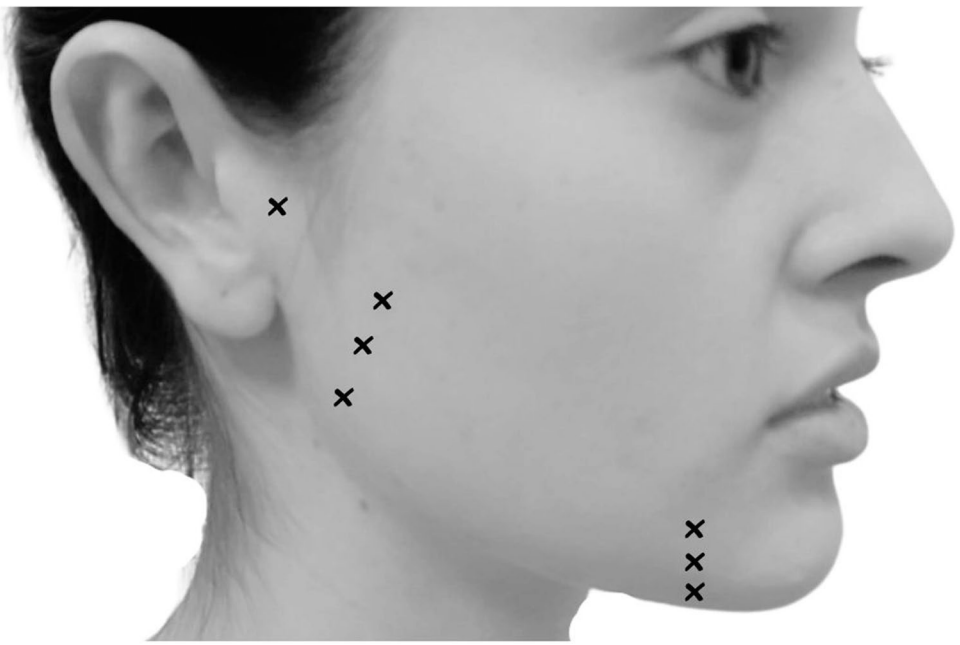

Fig. 1 Irradiation sites

6. If there is a deviation during opening, contain the deviation with your hand on the ipsilateral side of the deviation;
7. Performing 12 sets of active lateralization of the mandible, with rests of 60 s every two sets, alternating sides, maintaining laterality for 5 s with a subsequent return to the resting position;
8. Performing 12 sets of active protrusion of the mandible, with rests of 60 s every two sets, maintaining the posture for 5 s with subsequent return to the resting position;
9. Masticatory training using a silicone hyperboloid to orient the change of the sides. Wide and slow masticatory movements were oriented to increase proprioception and range of movement without using force;
10. Orientation on maintaining the exercise at home, with the same sequence of exercises performed in therapy, twice daily;
11. According to the weekly therapeutic performance, orientations regarding the progression of food consistency, detailing the possibilities of food according to the consistency classification;
12. Orientation on maintaining alternate bilateral chewing and the volume of food per chewing shift.

The following data were recorded at the end of each therapeutic session: painful response to exercise, measured with VAS from 0 to 10; maximum interincisal distance in millimeters; and food consistency to be maintained at home until the next visit, registering the need to restrict food with masticatory needs.

The functional aspects were reevaluated at the end of the 4 weeks of intervention, equivalent to 1 month after the operation, maintaining the same outcome assessment protocol. The same protocol was repeated 3 months after surgery for late monitoring of the effects of the interventions. The treatment and assessment protocol proposed was maintained throughout the study without modifications. Figure 2 shows the study flowchart.

Data analysis

The data were analyzed using the SPSS v.22 software (Chicago; SPSS Inc). Data distribution was assessed using the Kolmogorov–Smirnov test and histograms. Quantitative variables were described from the mean ± standard deviation and qualitative variables from absolute (relative) frequency. Fisher's exact test and the chi-square test were used to compare qualitative variables and the paired Student's *t*-test for quantitative variables between groups at each treatment stage. The quantitative variables were analyzed using the ANOVA test and the qualitative variables using the Cochran Q test, considering a 95% confidence interval at a significance level of 5%, to analyze the therapeutic gains in comparing stages of treatment.

The study consisted of 248 hospitalized patients due to facial fractures, of which 38 met the criteria for initial assessment and preoperative follow-up. Fourteen individuals maintained their eligibility postoperative and were randomly allocated into the study groups.

All individuals underwent all assessment stages and treatment, with no loss of follow-up throughout the study and

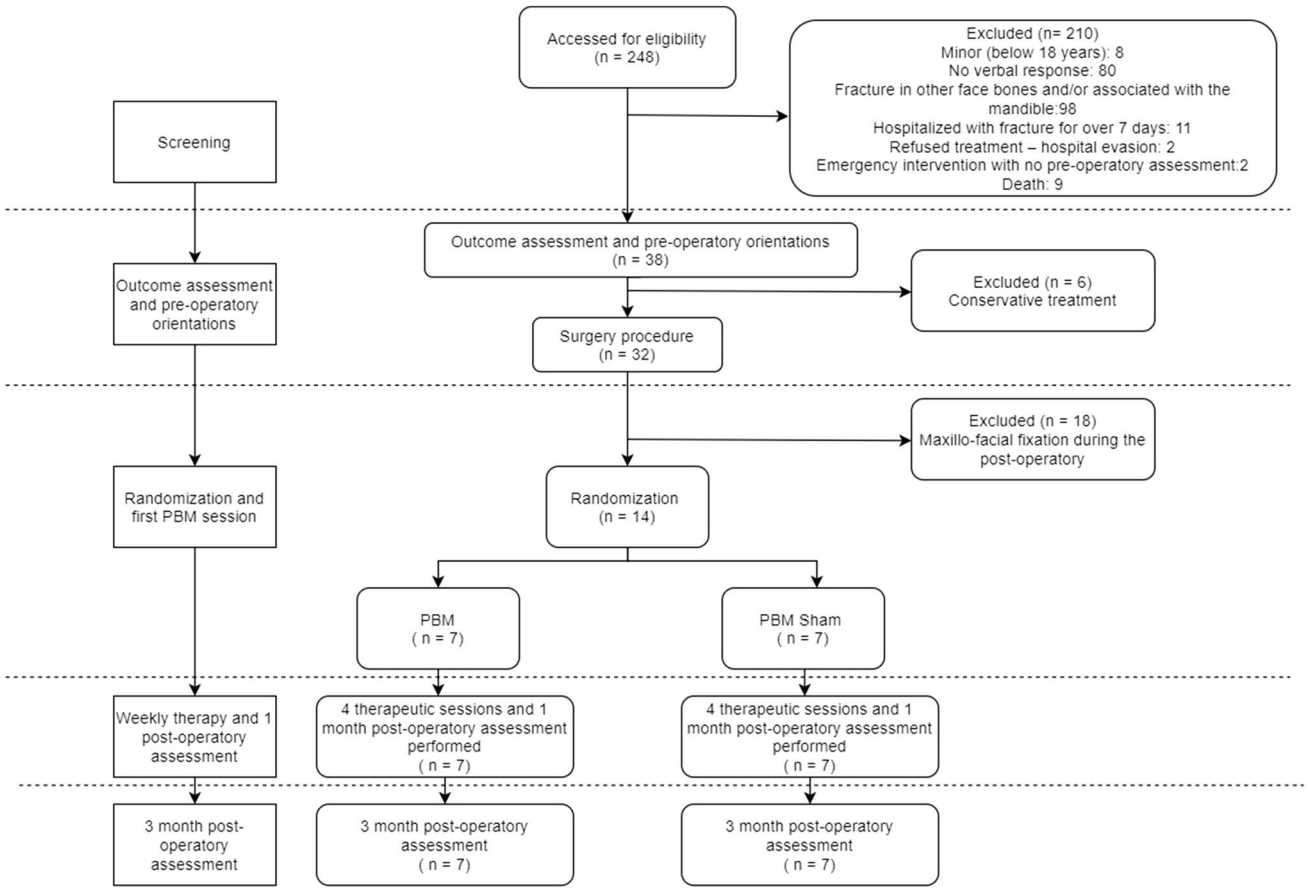

Fig. 2 CONSORT Flow diagram of patients enrolled in the study

without immediate or late complications after the surgical procedure (Fig. 2). The sample consisted of individuals with a mean age of 48.71 ± 15.11 years, predominantly male (71.42%), with hospitalization on the same date of the trauma. All presented simple, complete, and unfavorable fracture traces and underwent rigid internal fixation for bone repositioning. Both groups had similar hospitalization times until the surgical procedure and hospital stay. Table 1 describes the characteristics of the sample by study groups.

The evaluation data recorded over the 4 weeks of outpatient intervention are shown in Table 2. Individuals from the PBM group presented a less painful response to exercise in all weeks of intervention with a statistically significant difference compared to the sham group. Additionally, they presented a significant reduction in the painful response at week three compared to week one. In contrast, the sham group showed this reduction only at week four. Both groups showed progressive improvements when assessing the evolution of the maximum interincisal distance and food consistency consumed, with no difference between groups.

Table 3 shows the data for the assessment and comparison of the groups at each stage, in which there was no difference between the groups. Individuals in the PBM group showed a statistically significant reduction in pain at the mouth opening and improved the range of the laterality and mandibular protrusion movements 1 month after surgery compared to the preoperative. On the other hand, the PBM sham group showed significant improvement only after 3 months postoperatively. Furthermore, individuals in the PBM sham group persisted with pain in mouth opening 3 months postoperatively, with no persistence of the complaint in the PBM group. Both groups reached normality parameters of the maximum interincisal distance and predominance of individuals without restrictions on food consistencies 1 month after the surgical procedure. There was no difference between and within groups during the follow-up regarding the sensory aspects.

Discussion

This study allowed us to identify that the mandibular movements and masticatory capacity of foods with different consistencies reached normal parameters 1 month after surgical

Table 1 Demographic and clinical characteristics of the sample

	PBM	PBM sham	*p*
Sex			
Female	1 (14.30)	3 (42.90)	0.55
Male	6 (85.70)	4 (57.10)	
Age (in years)	51.84 ± 17.31	45.58 ± 13.11	0.61
Ethnicity			
White	5 (71.40)	4 (57.10)	0.57
Black or Brown	2 (28.60)	3 (42.90)	
Schooling			
Complete basic education	2 (28.60)	1 (14.30)	0.29
Complete high school	5 (71.40)	3 (42.85)	
Incomplete higher education or above	0 (0)	3 (42.85)	
Family income (in minimum wages)			
Up to 2	1 (14.30)	2 (28.60)	0.60
Between 2 and 3	4 (57.10)	2 (28.60)	
Between 3 and 4	2 (28.60)	3 (42.90)	
Alcohol consumption			
Ocasional—drinks 1–3 ×/month	5 (71.40)	6 (85.70)	0.50
Frequent—drinks 1–4 ×/week	2 (28.60)	1 (14.30)	
Smoking			
Yes	1 (14.30)	1 (14.30)	0.76
No	6 (85.70)	6 (85.70)	
Cause of the trauma			
Traffic accident	1 (14.30)	1 (14.30)	0.26
Sports accident	2 (28.60)	0 (0)	
Agression	3 (42.90)	5 (71.40)	
Fracture in dental procedure	1 (14.30)	1 (14.30)	
Side of the fracture			
Unilateral	3 (42.85)	3 (42.85)	1
Number of fracture traces	1.57 ± 0.53	2 ± 0.98	0.33
Location of the fracture			
Condyle	2	2	0.75
Angle	5	1	
Body	3	4	
Parasymphysis	1	3	
Days of hospitalization before the surgery	4.43 ± 2.44	7.29 ± 5.31	0.22
Time of hospitalization in days	10.86 ± 13.06	11.14 ± 6.33	0.95

Caption: *PBM*, photobiomodulation therapy; mean ± standard deviation; *n* (%); minimum wage in 2020, R$ 1,045.00

intervention in patients who underwent an oral exercise program. Furthermore, the ones exposed to PBM showed better pain response to motor stimulation and mouth opening, while participants in the control group remained complaining of pain 3 months after surgical intervention.

Limitations of mandibular movements during speech and eating are common during the recovery of individuals who suffered from mandibular fractures since the discomfort associated with surgical manipulation, presence of edema, and sutures generate discomfort that impedes the physiology of the stomatognathic system. However, these patients must be carefully monitored since the impacts of surgery can be prolonged [1, 7]. The literature commonly describes late functional restrictions in individuals with mandibular fractures due to complaints of limited mandibular movements and persistent pain [6, 15].

Muscle rehabilitation enhances the post-traumatic functionality of the mandible. The practice of oral exercises improves the range, symmetry, and adaptation of movements, reducing trismus and restoring stomatognathic functions early [7, 24]. Despite this, clinical protocols that describe treatment techniques and periodic interventions

Table 2 Comparison between the groups over the 4 weeks of intervention

	Week 1			Week 2			Week 3			Week 4		
	PBM	PBM sham	*p*	PBM	PBM sham	*p*	PBM	PBM sham	*p*	PBM	PBM sham	*p*
Pain when exercising	3.57 ± 0.53	4.43 ± 0.53	< 0.01*	2.43 ± 0.53	3.71 ± 0.95	< 0.01*	1.57 ± 0.97[a]	3 ± 1.41	0.04*	0.71 ± 0.75[b]	1.86 ± 1.21[b]	0.05*
Maximum interincisal distance	23.92 ± 2.96	23.42 ± 3.87	0.79	29.15 ± 2.54	27.82 ± 3.81	0.45	34.05 ± 2.29[a]	32.55 ± 3.73[a]	0.38	39.95 ± 1.52[b]	38.07 ± 2.35[b]	0.10
Diet												
With restrictions	7 (100%)	7 (100%)	1	7 (100%)	7 (100%)	1	3 (42.9%)	5 (71.4%)	0.29	0 (0%)	2 (28.6%)	0.23

Caption: *PBM*, photobiomodulation therapy

*$p < 0.05$ (PBM vs. PBM sham)

[a] $p < 0.05$ (week 3 vs. week 1)

[b] $p < 0.05$ (week 4 vs. week 1)

are scarce. In this study, early oral mobilization, initiated with orientations for the home practice immediately after the procedure and assisted exercises 1 week after the surgical intervention, proved effective for the investigated outcomes and without adverse effects for surgical healing.

Clinical protocols for the rehabilitation of oral functions in patients with mandible trauma are poorly described, and different techniques have been investigated to promote the rehabilitation of stomatognathic functions [6]. In addition to the practice of oral exercises, the use of PBM has been described as a strategy that facilitates the mobility recovery process and pain control in different areas of oral surgery. A previous study with patients who were victims of mandibular trauma showed a significant improvement in laterality and mandibular protrusion movements, with no significant impact on mouth opening when using the technique [3]. The use of PBM brought no lasting effects in the gain of mandibular range in individuals with neurogenic trismus when used as an isolated technique [8]. However, the association between the use of PBM and oral exercises improved functionality concerning isolated techniques in individuals with alteration of the temporomandibular joint [25]. As in these findings, the present study results indicate that the practice of oral exercises is an important strategy in the recovery of oral functions, providing a significant gain in the maximum interincisal distance in both groups. The use of PBM resulted in additional gain with pre-exercise pain control, generated a greater comfort in muscle intervention, and an earlier persistent analgesic control in spontaneous mouth opening when compared with the control group.

Photobiomodulation acts in the modulation and control of the inflammatory process, stimulates angiogenesis, promotes analgesia, and reduces the action of nociceptors, increasing endorphins, dopamine, and serotonin [3, 8, 9, 26–28]. When applied to skeletal muscle, this technique promotes recovery and muscle strength gain when applied before performing exercises, improving rehabilitation after tissue injury [9, 29]. In this study, PBM application before performing oral exercises allowed a less painful response to the motor stimulus and significantly reduced persistent pain response, showing no painful response 3 months after surgical intervention. These benefits may be associated with improved muscle regeneration, inducing the formation of new muscle fibers and accelerating the tissue repair process, with the activation of metalloproteinases, increased mitochondrial respiration, and the synthesis of adenosine triphosphate (ATP), which accelerate the healing process [3, 10, 26, 29]. Its action in increasing ATP production may be related to muscle relaxation and increased local blood microcirculation, which helps in the removal of catabolites from the tissue [9], favoring functional muscle mobility.

The PBM protocols are quite different concerning the type of light, frequency, and irradiation points according to

Table 3 Comparison between the groups at each stage of assessment throughout the follow-up

	Pre-operatory		Post-operatory		1 month post-operatory		3 months post-operatory	
	PBM	PBM sham	PBM	PBM sham	PBM	PBM sham	PBM	PBM sham
Diet								
With consistency restrictions	7 (100%)	7 (100%)	7 (100%)	7 (100%)	0 (0%)	2 (28.6%)	0 (0%)	0 (0%)
Maximum interincisal distance	18.49 ± 4.31	18.07 ± 6.57	20.40 ± 3.77	20.68 ± 4.5	39.95 ± 1.52 [a]	38.07 ± 2.35 [a]	41.28 ± 0.95 [b,c]	39.51 ± 2.13 [b,c]
Protrusion	1.07 ± 1.06	1.42 ± 1.04	1.64 ± 1.72	1.68 ± 0.86	4.35 ± 0.60 [a]	4.11 ± 1.16	4.9 ± 0.45 [b,c]	4.35 ± 0.93[b,c]
Right laterality	2.95 ± 1.76	3.08 ± 1.41	4.25 ± 1.58	4.28 ± 0.99	8.48 ± 1.95 [a]	8.45 ± 2.11	9.71 ± 0.65 [b,c]	9.38 ± 0.65[b,c]
Left laterality	3.12 ± 2.40	2.51 ± 2.08	4.32 ± 1.9	3.88 ± 0.66	8.45 ± 2.11 [a]	8.48 ± 0.97	9.72 ± 0.51[b,c]	9.45 ± 0.69[b,c]
Pain during rest	3 ± 0.81	3 ± 1.72	2.43 ± 0.53	1.86 ± 1.35	0.71 ± 0.75[a]	0.43 ± 0.53 [a]	0[b,c]	0.14 ± 0.37 [b,c]
Pain in spontaneous mouth opening	3 ± 0.57	2.86 ± 1.57	2.43 ± 0.53	1.71 ± 0.25	0.57 ± 0.78[a]	0.57 ± 0.53	0[b,c]	0.14 ± 0.37[b]
Pain when palpating the fracture traces	3.14 ± 0.69	2.43 ± 1.27	2 ± 0.81	1.57 ± 0.97	0.86 ± 0.9 [a]	0.14 ± 0.37 [a]	0[b,c]	0 [b,c]
Complaint of change in sensitivity								
Yes	5 (71.4%)	6 (85.7%)	5 (71.4%)	6 (85.7%)	4 (57.1%)	6 (85.7%)	3 (42.9%)	5 (71.4%)
Objective change in sensitivity								
Changed	2 (28.6%)	4 (57.1%)	3 (42.9%)	4 (57.1%)	3 (42.9%)	5 (71.4%)	1 (14.3%)	3 (42.9%)

Caption: *PBM*, photobiomodulation therapy

[a] $p < 0.05$ (1 month post-operatory vs. pre-operatory)

[b] $p < 0.05$ (3 months post-operatory vs. pre-operatory)

[c] $p < 0.05$ (3 months post-operatory vs. post-operatory)

the clinical objective to be achieved. We decided to propose a protocol combined with oral exercise sessions that could favor PBM benefits due to the scarcity of protocols aimed at patients suffering from a mandibular fracture, maintaining a reduced frequency of interventions for better therapeutic adherence. Thus, the use of infrared PBM with application in the muscles, joint, and bone injury areas was listed as a strategy to promote deep tissue repair, especially due to the deleterious muscular response resulting from protective restraint, favoring the muscular benefits already described, which were effective.

Despite the important results obtained using PBM for a pain response to exercise and spontaneous mouth opening, some notes are necessary regarding the study's limitations. Individuals from both study groups showed sensory changes since the trauma, which lasted 3 months after surgical intervention, with no benefit in using PBM. After a trauma, the sensory perception can be altered by partial or complete damage to the nervous structure, which must be specifically treated along the injured nervous pathway, using a higher periodicity of intervention [29]. Thus, the established clinical protocol may have been insufficient to favor the nervous lesion caused by the trauma since the sensitive pathway was not directly addressed by the irradiated points and the wavelength used did not effectively reach a sensitive repair. Furthermore, the data should be carefully analyzed to generalize the data for a population profile not covered by this study's exclusion criteria, such as fractures with an indication of a maxillomandibular block and conservative bone fracture management due to the small sample size allocated in the study.

Conclusion

The data obtained in this study showed that the proposed clinical protocol based on performing early oral exercises maintained weekly during the first postoperative month in patients affected by mandibular fracture treated surgically was effective and safe to restore oral functions, favoring eating without restriction of consistencies. PBM therapy weekly in the fracture regions, temporomandibular joints, and masticatory muscles promoted a greater reduction of immediate and late pain, resulting in greater therapeutic comfort. PBM's association with the oral exercise protocol was superior to the isolated exercises protocol in the postoperative management of patients with mandibular fractures who received surgical intervention, and its use is recommended. Thus, we suggest that this protocol may be incorporated into clinical orientations for guiding clinical practice.

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