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LITERATURE REVIEW:

Resorbable Osteosynthesis in Mandibular Fractures. An Exploratory Systematic Review

Osteosíntesis reabsorbible en fracturas mandibulares. Una revisión sistemática exploratoria

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ABSTRACT: Mandibular fractures have a high prevalence in the maxillofacial region, often requiring surgical intervention. The gold standard for treatment involves open reduction with osteosynthesis using titanium plates. New biocompatible materials have been applied to address the complications and disadvantages of titanium plates, leading to the emergence of absorbable osteosynthesis plates. Understanding the effectiveness of titanium plates and absorbable osteosynthesis plates in the treatment of mandibular fractures helps determine the need to invest in new techniques with predictable outcomes. To describe the effectiveness of using titanium plates and absorbable osteosynthesis plates in the treatment of mandibular fractures. In August 2023, an exploratory systematic review of the available literature since 2018 on the use of absorbable osteosynthesis plates in mandibular fractures was conducted. PubMed, Scopus, and WOS were searched, including studies in English or Spanish. A total of 227 articles were obtained. After reviewing titles and abstracts, 29 articles were included for full-text reading. Nine duplicates were discarded, and 10 were excluded based on predefined criteria, resulting in a total of 10 articles for this study. Authors report that titanium plates exhibit less displacement of the contact surface in fractured segments due to a larger surface area, rigidity, and load-bearing capacity. Absorbable osteosynthesis plates are more flexible but are susceptible to greater deformation under significant masticatory forces, potentially leading to fracture opening and displacement of bone segments. Postoperative complications were analyzed, and no statistically significant differences were found. Titanium and absorbable devices did not differ in terms of biomechanical behavior and

postoperative complications in the treatment of mandibular fractures. Further studies comparing both types of plates in mandibular fractures are needed.

KEYWORDS: Resorbable osteosynthesis; Titanium plates; Mandibular fracture; Resorbable fixations; Resorbable plates.

RESUMEN: Las fracturas mandibulares poseen una alta prevalencia en el territorio maxilofacial, requiriendo, en su mayoría, resolución quirúrgica. El Gold Standard corresponde a la reducción abierta con osteosíntesis con placas de titanio. Nuevos materiales biocompatibles han sido aplicados con el fin de subsanar las complicaciones y desventajas de las placas de titanio, surgiendo las placas de osteosíntesis reabsorbibles. Conocer la efectividad de las placas de titanio y placas de osteosíntesis reabsorbibles en el tratamiento de fracturas mandibulares permite determinar la necesidad de invertir en nuevas técnicas con resultados predecibles. Describir la efectividad del uso de placas de titanio y placas de osteosíntesis reabsorbibles en el tratamiento de fracturas mandibulares. Durante agosto del año 2023, se realizó una revisión sistemática exploratoria de la literatura disponible desde 2018 sobre el uso de placas de osteosíntesis reabsorbibles en fracturas mandibulares, empleándose los buscadores PubMed, Scopus y WOS incluyendo estudios en inglés o español. Se obtuvieron 227 artículos. Después de la revisión de título y resumen, 29 fueron incluidos para lectura de texto completo, se descartaron 9 duplicados, 10 fueron descartados por criterios de exclusión, quedando en total 10 artículos en este estudio. Autores relatan menor desplazamiento de la superficie de contacto de las placas de titanio en los segmentos fracturados, por una mayor área de presión superficial, rigidez y fuerza de carga. Las placas de osteosíntesis reabsorbibles son más flexibles y están sujetas a mayor deformación ante fuerzas masticatorias de gran magnitud, pudiendo generar apertura de la fractura, desplazamiento de segmentos óseos. Se analizaron las complicaciones post operatorias y no presentan diferencias estadísticamente significativas. Los dispositivos de titanio y reabsorbibles no difirieron en términos de comportamiento biomecánico y complicaciones postquirúrgicas en el tratamiento de fracturas mandibulares. Faltan nuevos estudios que comparen ambas placas en fracturas mandibulares.

PALABRAS CLAVE: Osteosíntesis reabsorbible; Placas de titanio; Fractura mandibular; Fijaciones reabsorbibles; Placas reabsorbibles.

INTRODUCTION

Fractures are among the most common injuries to the facial skeleton. They primarily affect adult men (1, 2). The anatomical and functional characteristics of the jaw make its high prevalence of fractures translate into a high social, economic, and personal impact injury for both the patient and health systems (1,2). The aim of its treatment involves aligning the fractured segments using the least traumatic method, reducing the risk of complications (3). The current treatment methods used for mandibular fractures can be summarized as intermaxillary fixation with closed reduction, using bar and wire arches, or fixation with open reduction, using plates and screws (4).

Titanium plates and screws are currently considered the first option due to their operational benefits (5). However, over time it has been shown that their use brings possible complications related to their composition, material lifespan, interaction with the patient's tissues, disadvantages in certain groups, among others, given in the short, medium and long term (5,6). The search for new alternatives that minimize the problems that

have arisen with their use in mandibular fractures has led to the creation of a resorbable biological material (4, 5). Resorbable osteosynthesis is one of the most recent techniques used for the stabilization of mandibular bone fractures (6). These plates are made with polyglycolic acid, polylactic acid and their copolymers, biocompatible materials that are characterized by their ability to completely degrade over a period of 1 to 4 years (6). With the introduction of this technology, it was discovered that polylactic acid is not toxic, does not react with tissues, does not accumulate in vital organs and has a slow degradation process (6). Since then its application has evolved and over time significant results have been achieved in its research (7). This material offers advantages such as mitigating the risk of growth restriction in the pediatric population, plate infection, implant migration and the need for extraction through reintervention (5-7). Resorbable screws are monocortical, which mitigates the risk of damage to the tooth bud and the inferior alveolar nerve (6,7).

The existence of these two treatment alternatives generates the need to investigate the results obtained from their use in mandibular fractures in search of the alternative with fewer adverse effects and better stabilization of the bone structure. The objective of this exploratory systematic review is to compare the effectiveness of the use of titanium plates and resorbable plates in the treatment of mandibular fractures.

MATERIALS AND METHOD

An exploratory systematic review of the existing literature was conducted in relation to the results obtained in the rehabilitation of patients with mandibular fractures using resorbable or titanium plates and screws. The search for articles was carried out in August 2023 and the search engines PubMed, Scopus, and Web Of Science were used using the keywords: “Mandibular Fracture”, “titanium plates”, “resorbable fixation”, “resorbable plates”, “resorbable osteosynthesis”, applying the Boolean operator AND and OR to restrict some search criteria. No discrimination was made according to the type of study and the search was delimited to articles that were in English or Spanish and that were published between the year 2018 and the search date (August 2023). The search keys are detailed in Table 1.

The following inclusion criteria were considered:

- Mandibular bone fractures.
- Comparative studies between resorbable and titanium plates.
- Replicas of human jaws.

The following exclusion criteria were considered:

- Pilot studies.
- Studies conducted in animals.

The titles and abstracts of the studies obtained were reviewed by the researchers, considering the inclusion and exclusion criteria described above. The full texts were obtained and reviewed in a second instance to ratify compliance with the criteria and be included in this review.

Those articles included were analyzed by the researchers jointly and a comparative table was prepared with the main findings, observations, and conclusions of the publications (See Table 2).

RESULTS

The search yielded a total of 227 articles, a general review of title and abstract was carried out, where 198 were excluded from full text reading for not meeting the selection criteria. Subsequently, of the remaining 29 articles, 9 were discarded for being duplicates. The full texts of the remaining 20 articles were read, resulting in 10 articles that met all the characteristics to be included in this review (See Figure 1).

Regarding the study design of the selected articles, one cohort, three *in vitro* experiments, one systematic review and meta-analysis, one systematic review and case series are distinguished. The most relevant findings of each study are summarized in Table 2.

Table 1. Search keys used according to the search engine.

Engine	Search keys
Pubmed	((((Mandibular fracture[Title/Abstract]) AND (Titanium plates[Title/Abstract])) AND (Resorbable fixation[Title/Abstract])) OR (Resorbable plates[Title/Abstract])) OR (Resorbable osteosynthesis[Title/Abstract])
Web of science	((((TI=(mandibular fracture)) AND TI=(titanium plates)) AND TI=(resorbable fixation)) OR TI=(resorbable plates)) OR TI=(resorbable osteosynthesis)
Scopus	TITLE-ABS-KEY (mandibular AND fracture AND titanium AND plates AND resorbable AND fixation OR resorbable AND plates OR resorbable AND osteosynthesis)

Table 2. Summary and comparison of the reviewed works. Main findings and conclusions are presented.

Year	Author	Study design	Country	Sample size	Main findings	Complication
2019	Chocron Y., Azzi A.J., Cugno S.	Systematic Review and Meta-analysis	Canada	178 patients (reabsorbable) 180 patients (titanium)	Complication rate of patients treated with resorbable plates: 18.0%. Complication rate of patients treated with metal plates: 18.3%. The meta-analysis suggests that there is no evidence of superiority in terms of results according to the type of plate.	Grouped complications: Postoperative infection, wound dehiscence, hardware failure, and malocclusion.
2022	Latarullo Costa D., *et.al.*	*In Vitro* Experimental Study	Brasil	25 mandibles of polyurethane, grouped according to fixation	The resistance of the bilateral sagittal split ramus osteotomy was best achieved using two titanium miniplates and the resorbable KLS plate showed the worst resistance.	Decreased mechanical resistance against the simulation of the force applied by masticatory muscles.
2020	Sukegawa S., Yamamoto N., Nakano K., Takabatake K., *et al.*	*In Vitro* Experimental Study	Japan	32 replicas of hemimandibles, divided into groups according to type of fixation	Uncalcined and unsintered hydroxyapatite/poly-L-lactide (u-HA/PLLA) screws have less resistance than conventional titanium screws. In fixations with two screws, the bioabsorbable screw model had slightly lower resistance to vertical and horizontal loads for initial displacement than the titanium screw. Fixation with resorbable screws is desirable in case of fracture of the mandibular condyle head.	Rotation and displacement of the fractured piece depending on the applied force.
2019	Sukegawa S., Kanno T., Yamamoto N., Nakano K., *et al.*	*In Vitro* Experimental Study	Japan	20 replicas of hemimandibles, divided into groups according to type of fixation	The u-HA/PLLA bioabsorbable plate has a sufficiently high resistance in the two-plate fixation method. Titanium plates were more resistant than bioabsorbable plates in subcondylar fractures. The results suggest that fixation systems with titanium and bioabsorbable plates have similar mechanical resistance.	Lower mechanical resistance of the fixation when subjected to anteroposterior and lateromedial forces in subcondylar fractures.
2019	Zieliński R., Kozakiewicz M., Świniarski J.	Finite Element Analysis	Poland	Poly-L-lactic acid (PLLA) plates and 'A'-shaped titanium plates	In high condylar neck fractures, the surface contact pressure on the titanium plate is almost twice as low as in PLLA, but the contact area is larger in the Ti-6Al-4V manufactured plate. The displacement on the contact surface of the Ti-6Al-4V plate is 10 times less than that of the PLLA plate. In the fissures in the fixation, it was observed that the widest was in the PLLA plate. The distribution of reduced stresses was 4 times lower in PLLA, a material prone to greater deformation. The Ti-6Al-4V plate allows greater load force and makes the osteo fixation rigid.	Surface pressure according to the contact area of the type of plate. Displacement on the contact surface. Fissures of the fixation. Distribution of stresses.
2019	Park Y.W., Kang H.S., Lee J.H.	Cohorts	South Corea	30 patients groups: reabsorbable (16 people), titanium (15 people)	No patient suffered clinical complications.	Skeletal stability along the HA/PLLA mesh for osteo fixation compared to titanium miniplates. Relapses in the long and short term in both groups.

Year	Author	Study design	Country	Sample size	Main findings	Complication
2019	Cansel Dogru S., Cansiz E., Arslan Y.Z.	Case series	Turkey	Finite element analysis. Ten sets of computed tomography data were used	Values of the maximum average stresses occurred from the 10 jaws were below the elastic limit (108 MPa) of the bone tissue. The difference in the maximum average stress between the titanium and resorbable systems was significant. The maximum average displacement in the resorbable system was greater than in the titanium system. The maximum Von Mises stresses produced in the titanium plates were much higher than those produced in the resorbable plates. In terms of stresses, both plates serve for the rigid fixation system. The interfragmentary displacements between the fragments were greater in the resorbables because these are more flexible and have a greater stretching capacity.	Displacement of the plates against maximum average stresses.
2021	Pontell M.E., Niklinska E.B., Braun S.A., Jaeger N., Kelly K.J., Golinko M.S.	Systematic Review	USA	Records of 1,144 pediatric patients	The total complications in the titanium and resorbable groups were 14% and 10% respectively, and these were not significantly different. Patients treated by ORIF (open reduction and internal fixation) with titanium hardware were more likely to undergo elective hardware extraction. No patient in this study underwent elective hardware extraction in the resorbable group. Resorbable plates were most commonly used in the ORIF of condylar/subcondylar fractures. The use of MMF was greater in the resorbable group.	Sensitivity to temperature, corrosion, hypersensitivity reactions, hardware translocation through growing bone, chronic pain, and infection. Displacement of the inferior alveolar nerve in phases of temporary and mixed dentition. Displacement of the metal plate through the growing jaw affecting the dental germ. Swelling, formation of fistulas, sterile abscesses, osteolysis, fracture and/or dehiscence of the plate.
2018	Murat U., *et al.*	*In Vitro*	Sweden	16 polyurethane mandibles.	Titanium screws demonstrated greater stability. There are no statistical differences in the fixation of plate and screws of titanium and resorbables.	Failure in stability and fixation.
2018	Kim D.Y., Sung I.Y., Cho Y.C., Park E.J., Son J.H.	Retrospective cohort	South Corea	28 patients endoscopic ORIF in subcondylar fractures	Postoperative stability, fracture healing, intact and stable occlusion was maintained during the follow-up period in both groups. Both groups exhibited complete bone formation around the fracture lines or fading of the fracture lines.	Fixation of the plates, secondary surgery, and infection.

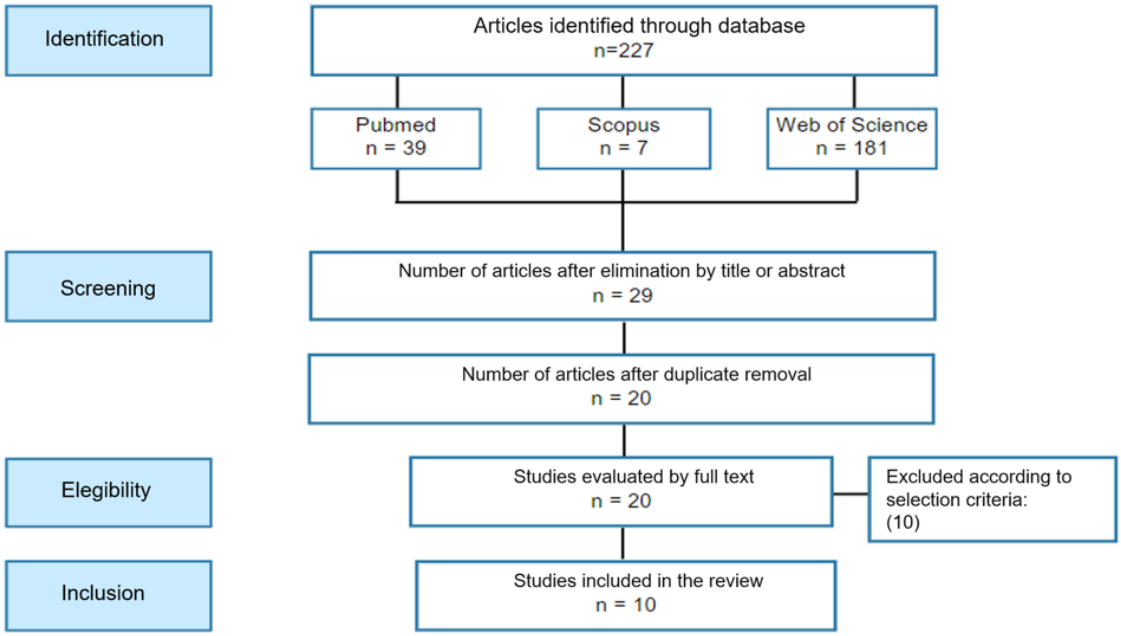

Figure 1. PRISMA Flow Diagram.

DISCUSSION

Biodegradable osteosynthesis devices are increasingly used in trauma cases to avoid problems associated with conventional metallic osteofixation (7, 8). With the emergence and increasing use of resorbable materials, controversy has arisen as to whether the traditional use of titanium plates for mandibular fractures has better results than more modern alternatives (8-10).

Among the main factors addressed in the articles included in this review are mechanical resistance, rotation and displacement against masticatory forces, surface pressure, distribution of stresses and forces, rates of postoperative complications (8-16).

Regarding mechanical resistance, they were fully evaluated in mandibular replicas simulating different types of fractures (7, 8, 11, 12, 14, 15). The resistance of resorbable plates in bilateral branch fractures showed worse resistance (7). However, in clinical situations with great bone contact, favorable movements, less influence on muscles and joints, both types of fixation can be used (7). In critical situations, rigid fixation is advisable. Al Morassi has shown a higher fracture of resorbable screws intraoperatively (7). On the other hand, in intracapsular fractures of the condyle head, titanium and resorbable screws did not show significant differences in large displacements, but in this type of fracture, fixation with resorbable screws is recommended (11, 12, 16.) In subcondylar fractures, the results suggested that both fixation systems have similar mechanical resistance (11, 12, 16).

High condylar neck fractures were studied using finite element analysis, yielding different conclusions. Regarding the surface contact

pressure, in titanium plates it was slightly lower than the resorbable ones and the contact area was larger in titanium (11, 12, 16). The displacement of the contact surface was greater in the resorbable one and the titanium ones presented a greater load force (11, 12, 16. That is, titanium plates have a larger contact area and load force, and less surface pressure, which favors the bone healing process due to a more rigid fixation (11, 12, 16). Resorbable plates, being more flexible, are subject to greater deformation, and when subjected to a masticatory force of great magnitude, it can generate the opening of the fracture and displacement of the segments, causing the degradation of the bone callus (11).

A systematic review evaluated the performance of both plates in pediatric mandibular fractures indicating that there was a 4% increase in postoperative complications in the titanium group (9). 90% of the treated patients underwent elective plate extraction (9). Likewise, a minimum percentage of patients required re-intervention and/or unplanned plate extraction (9). It was also concluded that the use of titanium plates and bicortical screws could affect the development and growth of the jaw (9). In patients with temporary or mixed dentition, the dental germ and the inferior alveolar nerve could be affected, favoring in these cases the use of resorbable screws, since being monocortical they decrease the damage to these structures (9). The rates of postoperative complications were not statistically significant in titanium and resorbable fixation (9). Among the variables analyzed by the researchers were the rates of postoperative infection, wound dehiscence, hardware failure, plate migration, sensitivity to temperature changes, corrosion, hypersensitivity, malocclusion, undergoing second surgeries, stress protection, chronic pain; thus suggesting that there is no evidence to demonstrate the superiority of one method over the other in terms of results between both fixation methods (9). Postoperative stability, fracture healing, intact and stable occlusion was the same in both groups exhibiting complete bone formation around the fracture lines or fading of the fracture lines, additionally no difference was evidenced in long-term skeletal stability (9). Among the limitations that arose during the development of this article, the lack of updated clinical trial research evidence stands out, which allows comparing the use and effectiveness of both types of plates in patients with similar characteristics. Having said this, it should be considered that those clinical studies are restricted by numerous bioethical norms. On the other hand, it is considered important to carry out research capable of analyzing variables in isolation, avoiding possible factors other than the type of osteosynthesis that may affect the result.

Being a recent technology, and still in development, there is little follow-up of long-term results, and little variability in the casuistry regarding the studied population. Therefore, it is important to increase the quantity and quality of studies that allow comparing, supporting or disapproving in a clear and significant clinical and statistical way these techniques.

CONCLUSION

Both fixation with titanium plates-screws and resorbable ones have been shown to be effective for the treatment of mandibular fractures, there are no statistically significant results to determine the use of one over the other. All this is influenced by age, location of the fracture, the direction of the forces and loads that the fractured area of the jaw will receive and the function it performs during occlusion and mastication. More evidence is needed, as well as increasing the number of patients intervened with both alternatives and studies that evaluate the clinical evolution and long-term follow-up.

The resorbable and titanium systems did not differ significantly in terms of biomechanical

behavior, neither of both hardware has a superior complication profile in the treatment of mandibular fractures.

Most of the included studies were *in vitro*, which can introduce biases in the results by not being exposed to natural loads and uses in a patient. Recent studies are lacking that compare the performance of both plates in human mandibular fractures, both in adults and children. Studies should take into account factors such as the complication rate, patient satisfaction and recovery, and associated costs. On the other hand, it would be interesting to compare the difference in results between adult and pediatric patients due to the different bone and functional requirements of each group. This could guide research towards a specific age group, being able to determine advantages according to level and type of development.

In the future, the results of clinical trials can provide high-level reliable evidence to help surgeons and patients make decisions about the treatment to choose in mandibular fractures.

AUTHOR CONTRIBUTION STATEMENT

Conceptualization and design: I.S.Z. y R.Q.A.
Literature review: M.C.D., D.F.F. y V.G.A.
Methodology and validation: I.S.Z. y R.Q.A.
Formal analysis: M.C.D., D.F.F. y V.G.A.
Research and data collection: M.C.D., D.F.F. y V.G.A.
Analysis and interpretation of data: M.C.D., D.F.F. y V.G.A.
Writing of the original manuscript: M.C.D., D.F.F. y V.G.A.
Review and editing: I.S.Z. y R.Q.A.
Supervision: I.S.Z. y R.Q.A.

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