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*Systematic Review*

# IMPACTED TEETH AND TEMPORARY ANCHORAGE DEVICES, A MODERN APPROACH: SYSTEMATIC REVIEW AND CLINICAL CASES

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## ABSTRACT

Dental impaction is a prevalent dental condition characterized by the improper eruption of a tooth, becoming trapped within the gum or jawbone. Detecting impacted teeth early is crucial for effective treatment. Temporary Orthodontic Anchorage Devices have brought about a transformative shift in the management of dental impactions, furnishing supplementary support and stability during the process of tooth repositioning. The research method involved a thorough search of PubMed, Web of Science, and Scopus databases from August 2013 to August 2023, using keywords "Miniscrew OR TADs" and "impacted OR included teeth," yielding 825 studies. After meticulous screening, 19 relevant articles were chosen for analysis. The review encompasses three case studies demonstrating successful tooth impaction resolution using miniscrews. The integration of skeletal anchorage with Temporary Orthodontic Anchorage Devices in orthodontic interventions has significantly expanded the treatment spectrum while concurrently enhancing efficiency. Notably, these modalities have exhibited promising outcomes in facilitating the repositioning of impacted teeth to their anatomically correct locations, thereby ameliorating both aesthetic and functional aspects. The use of Temporary Orthodontic Anchorage Devices offers several advantages, including a wider range of action, faster tooth movement and greater stability and accessibility without requiring the patient's cooperation.

**KEYWORDS:** *impacted teeth, canine, molars, TADs, miniscrew, included teeth, traction, dislocation, disimpaction, skeletal anchorage*

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## INTRODUCTION

Dental inclusions are a common problem in dentistry, attracting interest and attention from practitioners and researchers. They occur when a tooth fails to erupt properly in its natural position within the dental arch, becoming partially or completely trapped in the gum or jawbone. This condition can affect deciduous teeth and permanent ones (1, 2).

The eruption of permanent dental elements is the final stage in a complex series of genetically controlled events. Through these phenomena, a tooth bud develops in the maxilla or mandible by migrating in a coronal direction and erupts in the arch in its functional position according to predetermined times and paths. During this developmental process, however, numerous events can occur that interfere with the eruption of the tooth, leading to its inclusion, defined as a pathological condition that causes the failure to erupt in the oral cavity of a tooth element beyond the physiological limits of the eruption time, which represents a frequently encountered clinical picture, often associated with a transverse deficit of the upper jaw. Tooth retention must be distinguished from tooth inclusion: the latter is devoid of eruptive potential, the tooth root is fully formed, and the periodontal ligament is inactive (3, 4).

Epidemiological studies show an average incidence of dental inclusion of 20% in developed populations, with a slight prevalence for the female sex (5). The lower third molar (M3) is the most frequently included tooth, followed by the upper M3 and upper canine; the lower canines and other teeth follow less frequently. The upper canine is second only to the mandibular M3 in frequency of inclusion (6).

The prevalence of canine inclusion fluctuates from one epidemiological study to the next, depending on the composition of the groups examined in terms of ethnicity, gender and other variables; in fact, the disease is more represented, for example, in European populations than in Asian populations, in the female sex than in the male, and manifests itself much more frequently in the upper jaw; in 8-10% of cases, it is bilateral (7-9). The prevalence of canine inclusion varies from a minimum of 0.92% to a maximum of 4.3%. The incidence of permanent canine inclusion is approximately 2% of patients undergoing orthodontic treatment (10-16).

Inclusion is much more frequent in the upper than the lower jaw with a ratio of 10:1 (17), canine inclusion in deciduous teeth is very rare (18), in the mandible, dental inclusions occur more frequently in the vestibular area (19), mandibular canines included have a prevalence ranging from 0.05% to 0.4% (20), The female sex has a higher incidence of inclusion, with a ratio ranging from 2:1 to 3:1 compared to the male sex (21, 22), Inclusion or retention of second molars (M2) is a relatively rare condition (23).

Dental inclusion can be caused by several factors, including limited space in the dental arch, incorrect position of the dental germ during embryo development, physical obstacles, or other skeletal abnormalities (24-27). In addition, genetic factors, dental trauma, or inflammation may increase the risk of tooth inclusion (3). The diagnosis of tooth inclusion, or the suspicion that it may occur, must be made early, because many of the causes that contribute to hindering eruption can be removed if detected earlier than the average age of eruption, facilitating and reducing treatment time (10, 28).

Confirmation of the diagnosis of tooth inclusion is done through panoramic radiographs and 3D computed tomography (CT) scans to obtain more detail on the position of the included tooth and its relationship to adjacent teeth (29-32). Panoramic radiography can also detect any dental abnormalities associated with malposition of the canine in the palatal direction. Cone-beam CT (CBCT) is a 3D imaging technique that provides detailed and dynamic images of the skull and face, allowing a more precise assessment of the position of the included tooth (33-35).

Temporary Orthodontic Anchorage Devices (TADs) provide additional support and stability during tooth movement. The incorporation of TADs into orthodontic treatment has revolutionised the management of the most difficult malocclusions and significantly expanded the range of orthodontic movements that can be achieved (36). Several authors have demonstrated the effectiveness of TADs in the treatment of dental inclusions, proving to be a valuable aid in the resolution of included teeth by guiding the element into its correct position, with significant aesthetic and functional improvement (37-39).

The lack of osseointegration of titanium TADs contribute to instability and a relatively high failure rate, miniscrews are usually subjected to immediate loading and have a success rate of 50% to 89% (40, 41).

Immediate failure occurs when the insertion site is unsuitable such as areas with poor cortical bone or alveoli that have recently undergone extraction or due to incorrect handling during insertion such as a sudden change of insertion. Delayed

failure, on the other hand, includes overloading of the helix component or a sudden blow to the head of the TADs during mastication (36, 41-46).

In this article, we will examine the effectiveness of TADs as an anchorage method for dental inclusions. We will analyse the various treatment techniques using TADs that various authors over the years have used to resolve dental inclusions to improve dental function and aesthetics. The field of orthodontics has long been dedicated to achieving optimal occlusion and aesthetic results for patients. The advent of TADs has opened new possibilities, enabling more precise and efficient treatment approaches.

**Fig. 1.** *Pretreatment X-ray orthopantomography showing the two impacted upper canines.*

## CLINICAL CASES

*Case report 1*

A 40-year-old patient at the start of the treatment. Contraction of the upper arch and palatally impacted and mesioinclined 1.3 and 2.3 were diagnosed. 2.3 elements presented an unfavourable position for recovery. The mechanics used involved two orthodontic TADs (1.6 mm diameter × 8.0 mm length) positioned in the lower arch in 35 and 45 areas. After disinclusion surgery, an elastic band (1/2 " - 16 ounce) was applied with the function of pulling the canine by anchoring it to the TADs. The patient wore the elastic all day long, removing it only during meals. The elastic was changed every 15 days. Disinclusion with miniscrews took place over the course of 10 months during which time the upper multibrackets therapy was placed to reposition the 13 and 23 in the arch after upper tooth alignment. The patient is currently still undergoing treatment. Patient records are reported in Fig. 1-3.

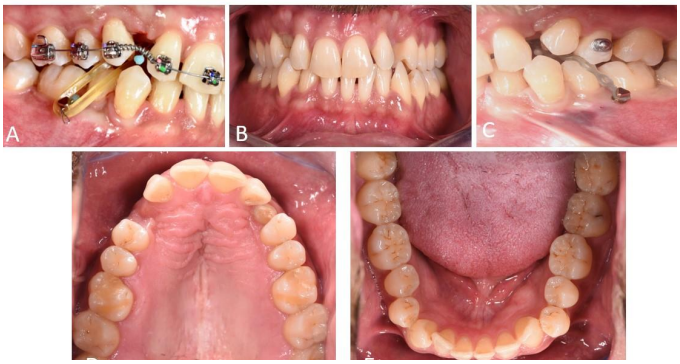


**Fig. 2.** *Intraoral patient's photos collage: right side view with TAD and upper multibrackets therapy (A), initial frontal view (B), left side view with TADs and metallic button (C), initial upper occlusal view (D), and lower occlusal view (E).*

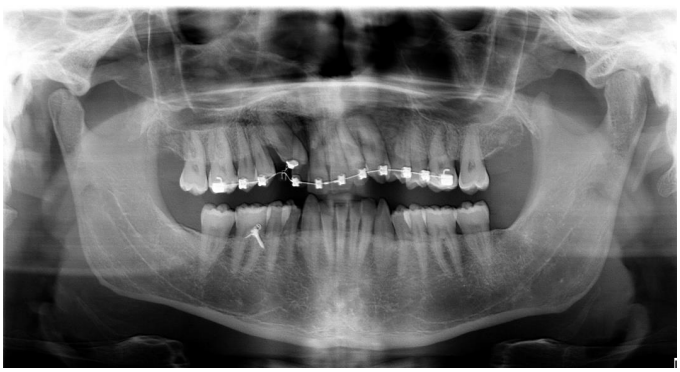

**Fig. 3.** *In treatment X-ray orthopantomography.*

*Case report 2*

A 21-year-old patient with 13 and 23 inclusions in palatal position. The disinclusion of both dental elements was carried out at the same time as the orthodontic multibracket therapy with the use of orthodontic miniscrews in the lower premolar area (35-45). The use of daily and overnight elastic traction allowed the dental to reposition over the course of 12 months in the correct area to allow correct intercuspation. The traction elastics used in this case are 1/2 " - 16 ounces replaced every 2 weeks. Patient records are reported in Fig. 4-6.

*Case report 3*

The procedure, used in the clinical case of a 14-year-old patient, allowed the palatally included maxillary canines to be disengaged using two TADs and an elastic chain. The patient's medical history did not show anything relevant. Intraoral examination revealed the presence of two deciduous canines, a molar class I and an inferior crowding.

The patient's need was to resolve the inclusion of the two canines. The treatment plan involved the use of an orthodontic-surgical technique combined with orthodontic miniscrews and an elastic chain. The patient was informed of the risks, advantages and disadvantages of this treatment approach and provided written informed consent to forego the procedures. The advantage is the presence of an orthodontic device in the oral cavity that allows good oral hygiene to be maintained without restricting chewing. In addition, orthodontic traction requires minimal patient collaboration (Fig. 7, 8).

The main disadvantage was the need for surgical exposure of the included canines. The surgical-orthodontic treatment involved exposing the included canines with a diode laser and placing the two TADs.

**Fig. 4.** *Pretreatment X-ray Orthopantomography showing the two impacted upper canines.*


**Fig. 5.** *Intraoral patient's photos: initial frontal view (A), in treatment frontal view (B), final frontal view (C), initial occlusal view (D), in treatment occlusal view (E), and final occlusal view (F).*

**Fig. 6.** *Post-treatment X-ray orthopantomography.*

## LITERATURE REVIEW

*Protocol and registration*

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used in this systematic review and submitted to PROSPERO with ID CRD 483337 (47). The information flow across the several stages of a systematic review is shown in the flow diagram. It illustrates how many records were found, how many were included, how many were excluded, and why. The article was structured following the main points of the PRISMA checklist and the division into paragraphs.

*Data sources and search strategy*

Three reviewers (V.S., L.R. and V.C.) performed an online search to set the topic. We used PubMed, Scopus and Web of Science as online databases, in which we searched for publications that matched the topic of the review. The search method was developed by analyzing articles that referred to fixed and mobile appliances used after orthodontic treatment and the occurrence of relapse after their use. After several searches, the final search was referred to a range of time from October 2013 to October 2023 using the keywords "miniscrew", and "TADs" with the Boolean variable "OR", "impacted" and "included" teeth with the Boolean variable OR. The two research are linked by the Boolean variable "AND" (Table I).

*Inclusion and exclusion criteria*

This research studies the use of TADs for the treatment and traction of impacted teeth. Articles that met several criteria were included:

**Table I.** *Article Screening Strategy.*

| | |
|---|---|
| Articles screening strategy | Keywords: (miniscrew OR TADs) AND (impacted OR included teeth) |
| | Boolean Indicators: ("A" OR "B") AND ("C" OR "D") |
| | Timespan: 10 years (2013-2023) |
| | Electronic Database: Pubmed, Web of Science, Scopus |

1. Study design: Randomized Clinical Trials (RCT), case series (CS), clinical trials (CCT), retrospective studies (RS), prospective studies (PS); observational study (O).
2. Human participants of any age
3. Any impacted tooth
4. English language
5. Only full text is available

Studies characterized by one of the following exclusion criteria were excluded:
1. Study design: reviews, letters, or comments, book, fee-paying pdf
2. In vitro studies
3. Animal models or dry skulls

*Data processing*

We excluded articles that did not fit the topic by reading the manuscripts' titles and abstracts. The full text of the remaining articles was read to assess the relevance based on the inclusion criteria. The study data was selected by analyzing the study design, number of patients, average age, intervention, type of treatment disimpaction and outcome. Disagreements between authors on article selection were discussed and resolved.

*Data extraction*

A standardized form was used to capture data on research design and locations, population characteristics (e.g., sex, age), type of intervention and comparison, baseline measurements, and reported results. Each study was also evaluated for its handling of missing data and effect measurements. For extraction accuracy, two reviewers (V.S. and F.P.) worked separately; divergences were resolved by consensus. Because of the substantial variability in the treatments and outcomes reported, meta-analysis was not possible; consequently, papers were synthesized qualitatively.

*Data analysis*

For homogeneous research, the fixed effect model was used, whereas, for heterogeneous studies, the random effect model was used. In all analyses, the effect size was calculated using the standardized difference of means.

*PICOS requirements*

The PICOS (Population, Intervention, Comparison, Outcome, Study Design) criteria, which are used in this evaluation, encompass population, intervention, comparison, outcomes, and study design (Table II).

**Table II.** *PICOS criteria.*

| **Criteria** | Application in the present study |
|---|---|
| **Population** | Young and adults |
| **Intervention** | Disimpaction of teeth by means of TADs |
| **Comparisons** | Comparison with other techniques |
| **Outcomes** | Analysis of timing and results of the traction |
| **Study design** | Clinical Trials |

*Quality assessment*

The quality of the included papers was assessed by two reviewers, R.F. and E.I., using the ROBINS, a tool developed to assess the risk of bias in the results of non-randomized studies that compare the health effects of two or more interventions. Seven points were

evaluated, and each was assigned a degree of bias. A third reviewer (F.I.) was consulted in the event of a disagreement until an agreement was reached.

## RESULTS

The electronic database search generated 825 results by entering the keywords (miniscrew OR TADs) AND (impacted OR included teeth) in three databases, including Pubmed (294), Scopus (129) and Web of Science (402). Following duplication elimination (274), 551 studies were screened reading title and abstract. After the abstract screening, 496 papers were rejected (10 reviews, 3 in vitro, 17 on animals, 7 weren't in English, 404 off-topic). Among the 55 articles selected, 2 texts were not retrieved, therefore 53 articles were chosen for the eligibility evaluation. Following the full-text examination, manuscripts were eliminated: 29 off-topic and 5 wrong settings. Finally, 19 papers were chosen for the systematic review. Fig. 9 summarizes the selection procedure.

The study data was selected by analyzing the study design, number of patients, average age, intervention, and outcomes (Table III).

*Quality assessment and risk of bias*

The risk of bias in the included studies is reported in Fig. 10. Regarding the bias due to confounding most studies have a high risk. The bias arising from measurement is a parameter with a low risk of bias. Many studies have a low risk of bias due to bias in the selection of participants. Bias due to post-exposure cannot be calculated due to high heterogeneity. The bias due to missing data is low in many studies. Bias arising from the measurement of the outcome is low. Bias in the selection of the reported results is high in most studies. The final results show that 9 studies have a high risk of bias, 3 have a very high risk of bias and four have a low risk of bias.

## DISCUSSION

*Molars*

Several methods have been devised for mounting impacted teeth angled mesially with direct or indirect anchorage with miniscrews. The larger wire width allows a wider range of action in the treatment

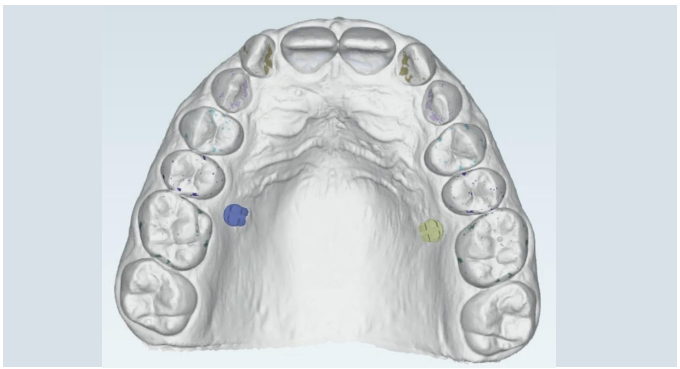

**Fig. 7.** *Digital upper arch impression with TADs*

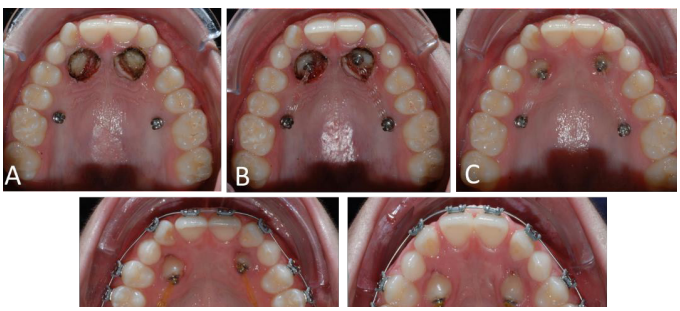


**Fig. 8.** *Intraoral occlusal view photos: After surgical explosion (**A**), elastic chain positioning (**B**), after 1 month check (**C**), after 2.5 months check with multibrackets therapy (**D**) and after 4 months check (E).*

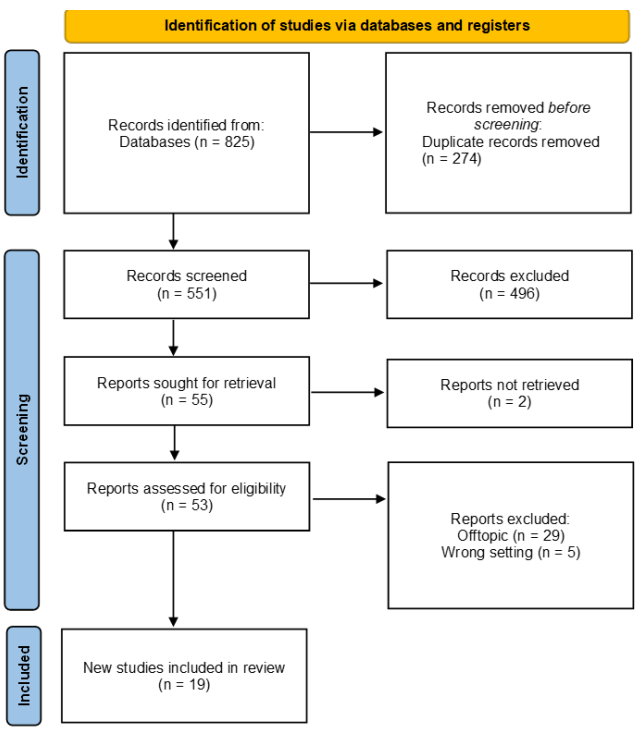


**Fig. 9.** *Literature search Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.*

**Table III.** *Characteristics of the studies included in the analysis.*

| Authors (Year) | Type of the Study | Aim of the Study | Materials | Results |
|---|---|---|---|---|
| Lorente et al. (2018) (48) | Case series | To induce the eruption of a profoundly impacted molar | A Cantilever arm supported by a miniscrew and a dental anchoring unit is used in a straightforward surgical approach. A "pole" functions as a first-order lever, with the resistance or charge represented by the unerupted molar and the fulcrum represented by the section of wire joined to form an anchoring unit. The force is generated by the miniscrew. | In both clinical cases, the use of the miniscrews caused the impacted molars to extrude, bringing them into balanced occlusion with the remaining dental parts. |
| Morita et al. (2020) (49) | Case report | The objectives of the treatment were creating a class I molar relationship, correct occlusion between the two arches, including the maxillary first molar (M1) and the impacted mandibular molars. | Two miniscrews were used, the first between the left second premolar and M1, the second miniscrew between the mandibular left canine and the first premolar. A transpalatal arch was used to prevent the molars from buccally tilting during intrusion. | Overjet and overbite were adequate, resulting in maxillary and mandibular occlusal interdigitation and a Class I molar attachment. The left maxillary first tooth was 3 mm intruded, whereas the left mandibular M1 was 60° upright and 6 mm extruded, according to a cephalometric superimposition. The total therapeutic period lasted two years and eleven months. |
| Baena et al. (2016) (50) | Case report | This study reports a case in which the lower M1 was recovered with orthodontic therapy combined with miniscrew, alloy Beta titanium (TMA) sectionals and oral surgery. | A 12-year-old female patient with an enclosed lower M1 had two miniscrews placed, one in the upper arch and a lever arm in (TMA 0.017x0.025) to intrude and create space in occlusion and one lower miniscrew between the first and second premolars and an extrusive lever arm in (TMA 0.017x0.025). | The miniscrews and sectional were removed after 24 months of therapy, the tooth was extruded and correctly brought into occlusion, also improving aesthetics. |
| Lorente et al. (2021) (23) | Two clinical cases | Conservative orthodontic treatment of eruption disorders of the permanent M2 in order to improve the occlusion of young patients. Treatment with TADs and TMA. | The two cases were solved by the use of a TADs acting as an anchor and a (TMA 0.019x0.025 inch) sectional arch exerting an extrusion force of 150-200 grams. the fulcrum of rotation of the TMA sectional arch is a (0.019x0.025) steel sectional arch bonded on the teeth adjacent to the tooth to be extruded. | This technique is a surgically performed orthodontic procedure to force the eruption of included M2s. This device uses mesial TADs that allow the application of an extrusive force in a short period in the first case 45 days in the second case four months. |
| Lorente et al. (2022) (51) | A prospective follow-up study | The study objective was to analyse the effectiveness of the author's "orthodontic technique to facilitate M2 eruption in the presence of complex molar inclusion indicators. | During 2 years, an observational prospective study was conducted. Baseline (T0) measurements of sociodemographic, clinical, and low-dose scanner characteristics were made. The follow-up variables (T1) included the interval between the procedure and the eruption of the M2, radiographic measures, button debonding, miniscrew failure rate, and success rate of eruption. 13 of the 24 molars were maxillary | The technique applies forces that succeed in extruding the included M2s in a short period and with a low failure rate. the treatment time variable depends on the severity of the infraocclusion of the tooth and the inclination of the tooth. |
| Altieri et al. (2020) (37) | A case report | The author presents a combined orthodontic-surgical technique for the disinclusion of the mandibular second molar M2. using orthodontic TADs and an elastic chain. | Orthodontic surgical technique on a 12-year old female patient, involving the use of a 13 mm long, 2.3 mm wide TADs placed in a retromolar area after removing the M3, and an elastic chain pulling the two included molars connected to two buccal and lingual buttons. | In a single surgical time, surgical removal of the lower M3, insertion of the miniscrew and orthodontic traction are performed, allowing a conservative treatment approach. After 3 months, the included tooth has achieved a good occlusion. |
| Mah et al. (2015) (38) | Case series | To demonstrate a biomechanical system that employs two miniscrews and a connecting wire to straighten mandibular teeth. | The procedure employs two miniscrews with an area for an orthodontic wire. | The impacted molar was effectively uprighted without interfering with the original occlusion or the alignment of the surrounding teeth. |
| Zhao et al. (2023) (52) | Clinical Trial | The current surgical procedure for extracting such Impacted lower M3 is either ineffective or time-consuming. A more effective surgical design is required. | Dr. Zhao retrieved Impacted lower M3 from 23 people who were found to have impacted lower M3 around the IAC between August 2019 and June 2022. These patients had their impacted lower M3 extracted by coronectomy-miniscrew traction. | The interval between coronectomy-miniscrew insertion and impacted lower M3 removal was much shorter compared with regular orthodontic traction. |
| Cortes et al. (2014) (53) | Case report | To prevent the danger of Inferior Alveolar Nerve (IAN) damage, the lower M3 was extruded using an orthodontic miniscrew prior to surgical removal. | An orthodontic miniscrew was placed between the first and second antagonist maxillary molars in the buccal cortex. Two orthodontic elastics were used to apply traction between the miniscrew and the orthodontic hook positioned on the lower M3 occlusal surface. | A CBCT imaging follow-up validated the lower M3 orthodontic extrusion's success. |

| | | | | |
|---|---|---|---|---|
| Baik et al. (2016) (54) | Randomized Controlled Trial | To examine if vertical eruption of affected M3 improves after second molar mesialization and what factors influence vertical eruption of impacted M3 when lacking molar space is effectively repaired by second molar mesialization using miniscrews. | The study comprised 52 patients with missing mandibular M1 or missing deciduous mandibular M2, initially impacted mandibular M3, and effective edentulous gap closure with orthodontic. The control group (Group 2) included 46 individuals with impacted mandibular M3 who did not receive molar protraction therapy. | M3 in Group 1 erupted vertically an average of 2.54 mm compared to 0.41 mm in Group 2. |
| Greco et al. (2022) (55) | Case report | The study aims to treat impacted canines with a combined approach using TADs and aligners | In the first scenario, the affected canine's space is recreated, the malocclusion is corrected using an aligner device, and TADs are then used to attempt to de-impact the canine. The second clinical scenario involves a de-impaction stage that occurs right away and relies only on the use of TADs and sectional wires, followed by a finishing phase with aligners. It is connected to the canine-first strategy. | Both methods of treating impacted canines are effective, but which one is chosen depends on the initial malocclusion and the amount of space that is available in the upper arch. |
| Noroozian et al. (2022) (56) | Case Report | This study analyses a method to guide palatally impacted canines into the dental arch | Two possible scenarios have been analysed: a first -canine approach and a first phase of space creation approach, depending on the needing of the space | The drawbacks of the traditional technique are not present with this technique. Additionally, compared to the conventional approach, the overall treatment time and the time that orthodontic appliances are in the mouth cavity are shorter. |
| Venugopal et al. (2020) (57) | Case Report | This study aims to assess the validity of the miniscrew for the treatment of labially impacted canine | It has been used a power arm on the exposed canine and a TAD on the opposite arch | The use of TAD in the opposite arch is a valid solution in the traction of the upper canine. The referred problem is the discomfort of the patient |
| Venugopal et al. (2021) (58) | Case Report | The study aims to assess the validity of TAD to disimpact a palatally impacted canine | 17 years-old patient was treated with TAD on the opposite arch and a power arm on the exposed canine | In less than 11 months, the impacted tooth was successfully brought into occlusion. |
| Jung et al. (2021) (59) | Case report | Before surgical removal, the lover M3 was extruded with an orthodontic miniscrew to reduce the risk of inferior alveolar nerve injury. | Orthodontic extrusion of the Lover M3 using a miniscrew inserted on the maxilla and an intermaxillary elastic band without bracket connection to the surrounding teeth. | Cross-sectional CBCT pictures taken 3 months following the first application of the orthodontic force revealed that the nerve and root had been separated, and extraction was conducted. We discovered a 3-mm upward migration from the mandibular canal, equal to 0.75 mm each month. Furthermore, because traction was administered on the palatal side, the teeth were inclined 5 degrees toward the lingual side. |
| Bellot - Arcis (2021) (60) | Case report | Use of miniscrews to distalise the entire mandibular arch and canine disinclusion. | TADs for canines included | The miniscrews were placed in the retromolar area to straighten the mandibular molars, distalise the entire mandibular arch and prevent the maxillary incisors from tilting excessively. |
| Chang et al. (2016) (61) | Case report | Canine disinclusion | Two palatal TADs were used to distalise the maxillary dentition. | The inclusion of canines caused significant root resorption in four maxillary incisors. In 25 months of treatment, two palatal TADs were used to distalise the maxillary dentition. |
| Galluccio et al. (2021) (62) | Case report | Approach with the bone tunnel technique | TADs and canines included | The subperiosteal tunnel access technique with vertical incision (VISTA) is an effective method about the direction of forces and periodontal conditions of the included canine. It is done by means of an elastic chain connected in the posterior area with a temporary anchoring device (TAD). |
| Migliorati et al. (2021) (63) | Case report | Evaluation of two anchoring systems | Miniscrews and palatal bar | The study conducted canine disinclusion using two techniques. The test group received treatment using a mini-screw as anchorage, the control group was treated using a trans-palatal arch anchorage unit. |

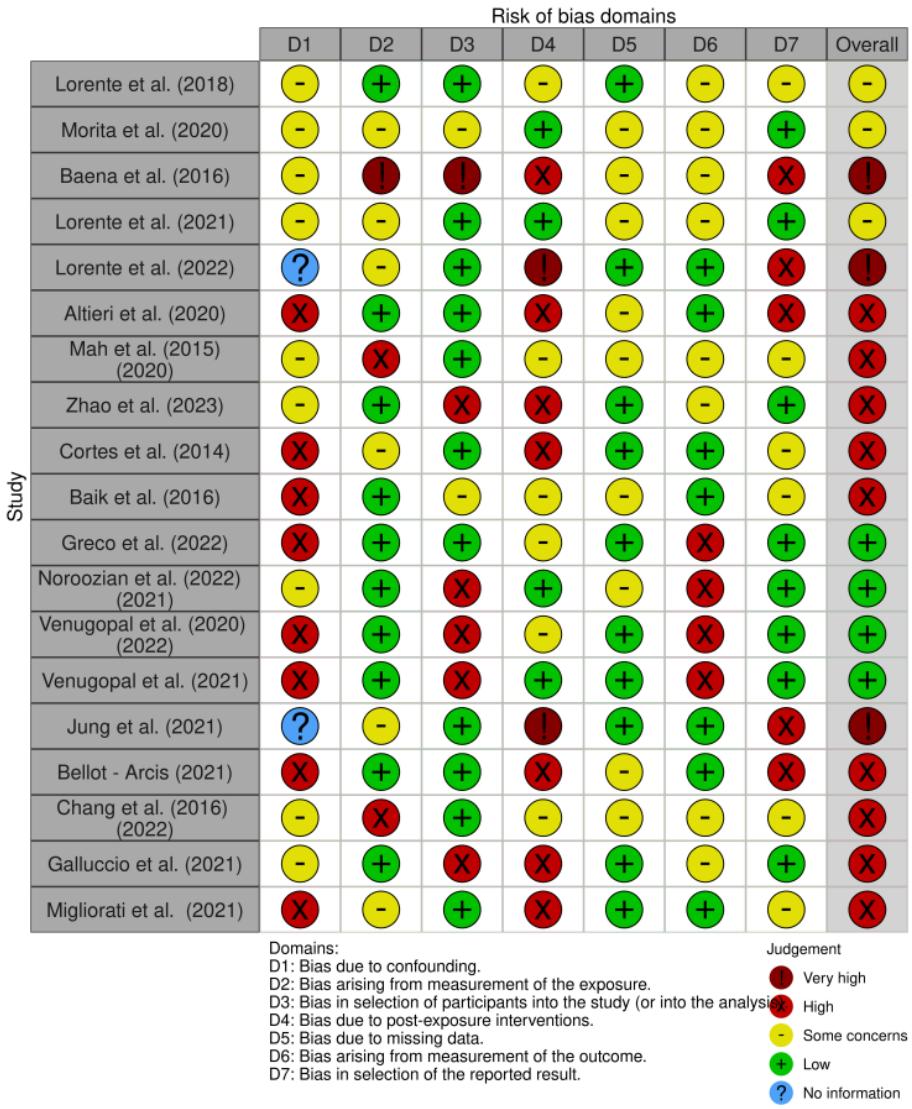


**Fig. 10.** *Risk of bias evaluated through ROBINS tool.*

mentioned by Lorente et al. and enables effective tooth movement. As the force used in the described technique is equal to the 50-150 g used in other procedures, the molar eruption can occur more quickly. The cantilever fits easily on the miniscrew for fast activation (48). After the procedure, there is no need to replace chains, elastic wires, or springs. If the miniscrew is placed mesially to the ectopically erupted molar, stability and accessibility are improved. If the miniscrew is inserted distally, in most cases, removal of the M3 and a healing time will be required before the necessary anchorage can be fixed. The M3 is only removed if the miniscrew blocks the crown of the second molar and the lack of space prevents the eruption of the second molar.

According to the author, the cantilever approach is used to resolve the dislocation of difficult molars and guide the tooth correctly into the arch without complications. Although this technique has mainly been used on M2, it has also been performed on M1 and lower canines (48). The approach presented by Mah et al. employs two miniscrews as orthodontic brackets and employs a rectangular connecting wire to manage the affected molar position in three dimensions (38). With

miniscrews, this approach combines the benefits of direct and indirect anchoring.

Without several brackets on teeth, different creative wire patterns (loops or helices) may be used to erect and regulate the molar position. The appliance system is less complicated and provides for improved oral hygiene without the danger of decalcification or gingival issues. They also demonstrated a three-dimensional force being applied to the tooth through a wire connected to a bracket with a specific orthodontic abutment attached to a miniscrew with a particular inner thread pattern on its head (38). The built-in rectangular groove that links the two miniscrews is used in their system. In patient 1, one of the two miniscrews on the left side came out before the procedure of uprighting the molar began, therefore only one miniscrew was used. The left miniscrew was strong enough to bear the uprighting force: the moment produced by uprighting the molar was clockwise, which helped tighten the miniscrew into the bone (38).

The main results in this situation were twofold: the miniscrew may survive if the thread direction can endure the moment induced by the uprighting force, and the molar position may be appropriately managed if the slot length of the miniscrew head is long enough to firmly grasp the wire. In the three patients, vertical and horizontal wire loops were used. Initially, distalizing tension was applied to the crown of the impacted or mesially pointed molar using several vertical looped wires. An open-coil spring can be used instead of vertical loops to enable the distalizing force of patient 1's molar. Their observations show that loops outperform coil springs (38).

*M1 and M2*

The inclusion of the M1 is an extremely rare event. In the case of Morita et al., an uprighting cantilever was utilized to upright and extrude the M1 because the cantilever mechanics provide an uprighting moment and an extrusive force simultaneously, which is suited for correcting the angulated and inferiorly positioned molar (49). A miniscrew was placed between the canine and the first premolar, and the cantilever was hooked over the miniscrew head. The connection of a tube in the buccolingual direction, rather than the mesiodistal direction, was the most unusual component of the molar uprighting mechanics applied in this case. By twisting the distal end of the cantilever, an efficient distal tipping moment may be imparted to the molar. As a result, a miniscrew was placed between the canine and the first premolar to create a longer cantilever mechanism (49).

**Fig. 11.** *Insertion site of miniscrew for molar uprighting.*

The clinical case described by R. Rodriguez Y Baena concerns a 12-year-old patient who presented with a delayed eruption of the mandibular M1 on the right.

The treatment involved an intrusion of the right upper M1 with subsequent extrusion of the lower M1 including using TADs (50-64). On the mandible, TADs were placed between the first and second premolars connected to a cantilever in TMA 0.017x 0.025 exerting a vertical extrusive force on the lower molar included (65, 66). After 24 months, the tooth achieved proper occlusion with its antagonist. The TADs were removed at the end of the treatment (27, 67-69).

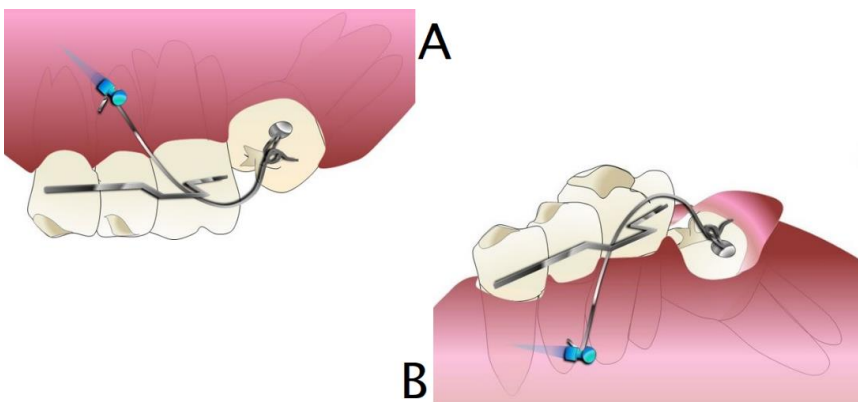


**Fig. 12.** *Traction of the impacted tooth using the Lorente technique. A: upper molar. B: lower molar with surgical exposure.*

Second molar inclusion is a rare condition. Lorente et al. in this paper describe two cases of included molars, in a 15-year-old and a 13-year-old (70). The authors opted for conservative orthodontic treatment with TADs between the first and second premolars. A 0.021 "x0.025" steel sectional was bonded to the three teeth adjacent to the included molar. This acted as a mesial step through which a Ni-Ti cantilever, exploiting its memory effect, generated an extrusive force of 150-200 grams to the included tooth (Fig. 11). The maxillary tooth included in the first case reached occlusion after 45 days, while in the second case after four months due to the increased mandibular bone density (23, 71).

Bereket et al., in their work, conducted a prospective observational study over two years, focusing on the eruptive technique of Lorente for M2 using TADs and Ni-Ti (Nickel Titanium) cantilevers (72) (Fig. 12). The study was carried out on a sample of 21 patients, with an average age of 13.9 years. Between the starting time (t0) of the study and the ending time (t1), the following variables were compared: the time elapsed between the surgical intervention and the eruption of the included tooth, the failure rate of TADs, radiographic measurements between the bone margin and the cusp of the included tooth, and the treatment success rate (51). Three cantilevers of different lengths were used to extrude the included tooth, selected based on the point of force application relative to the centre of resistance of the tooth. According to the authors, the angle and degree of infraocclusion of the included molar are variables that can particularly influence treatment times. Thanks to the adopted technique, all teeth were correctly erupted into the arch, except for two cases where perfect occlusion was not achieved (51). The failure of one TADs was also recorded. Compared to others, one advantage of this technique is that it can be performed on both the upper and lower jaw, providing good comfort to the patient. Finally, the main limitation of the study is the small sample size of included molars considered (51).

Altieri et al. present an orthodontic technique for the eruption of impacted lower M2 in a 20-year-old patient (37). The technique involves the surgical removal of the M3, the placement of TADs in the retromolar area, and an elastic chain connected to the second molar, bonded with two buttons, one on the buccal side and one on the lingual side. An early diagnosis and prompt treatment are the keys to success in the eruption of M2. The advantages of this technique are the absence of bulky devices that hinder chewing, the maintenance of good oral hygiene, and the lack of patient cooperation (37).

*M3*

Zhao et al. used a procedure comprising coronectomy, modified pericoronal ostheotomy and improved orthodontic extraction (52). Coronectomy reduces the resistance of the M3 extraction crown, provides sufficient space for miniscrew traction, and also creates a suitable surface for miniscrew implantation. The duration of extraction with this approach can be significantly shorter than that of standard orthodontic extraction, which can take months, after precise coronectomy, removal of the pericoronal bone and implantation of the miniscrew, and with adequate extraction force produced by the spring (52). In the case of Jung et al., the inferior M3 was close to the IAN, but it was still possible to remove it without causing nerve damage by using TADs and a cross band for 4 months (59). In this study, only one TADs was placed on the maxillary palatal side and only one button was connected to the inferior M3 to enable its traction. The use of a bone anchor in the opposite arch made it easier to manage the direction of traction and the angle of the teeth for the patient. When traction was applied to the palatal side of the maxilla, the teeth shifted lingually and the apex of M3 was separated from the canal horizontally and vertiginously. In this case, TADs were used as an anchoring device to provide a more predictable and safe therapy. Compared to other CT procedures, CBCT has several, advantages, including lower effective radiation doses, faster acquisition times, simpler imaging and lower costs (59). In the case of Cortes et al., elastic traction was also employed, resulting in a 5-week orthodontic treatment duration to achieve lower M3 extrusion (53). The hook was positioned on the lower M3 occlusal surface in this example, resulting in less contact with the patient's cheek mucosa; two elastics were used, reducing traction time. However, an initial surgical treatment utilizing a piezoelectric surgical device, which has been discontinued, was required to remove the bone around the occlusal and buccal surfaces of the lower M3 crown (53). Baik et al. investigated the factors associated with the vertical eruption of impacted M3 when room is obtained by uprighting with mesialization of the second teeth (54). Even though horizontal angulation was significant, as demonstrated by the distance between the ramus and M3, vertical eruption was detected. This implies that initial vertical position and available space are important factors in the eruption of impacted M3. As a result of uprighting with second molar mesialization, impacted lower M3 arise vertically (54).

*Canines*

With an incidence ranging from 1% to 5.9%, canines are most typically added after the M3. Canine impaction is most frequently related to lack of space, wrong development of the tooth position, an atypical eruption path, extra teeth, and genetic factors, according to the literature (73). The placement of the lateral incisor may be affected by how close the upper canine is to being affected. The lateral incisor's root may be pressed by the palatal canine, which will cause it to migrate in the direction indicated by the canine. The crown of the lateral incisor may positively deflect as a result of the canine's vestibular location (74). Since most retained canines exhibit mesioinclination, they frequently have a greater impact on the position of the lateral incisor than the first premolar (75).

Several treatment protocols have been developed over the years to be able to treat palatally included upper canines, including Ballista springs, interarch tractions, and wires Kilroy springs (19,57,76-78).

The age of the patient, the physician's ability and experience, predicted patient compliance, and most importantly anatomical location all influence treatment options (79).

The traditional approach to treating impacted canines with orthodontic surgery entails surgical tooth exposure using either the "open exposure" or "closed exposure" method, bonding an orthodontic button with the attached chain intraoperatively, and connecting it to the arch of the permanent appliance (80).

To avoid changing the occlusal plane and straining the neighbouring teeth, impacted canines must be removed using optimal biomechanics during orthodontic eruption (73). For instance, if anchorage is only provided by the brackets and archwire, this could result in a lateral open bite and bone loss distal to the lateral incisor (81).

Anchorage of a miniscrew (1.6 mm diameter × 8.0 mm length) to the arch opposite that in which the impacted canine is present and the use of an intermaxillary rubber band brought the canine into occlusion in about 11 months. The patient had to wear the rubber bands (1/8″, 4.5 oz) for about 8-12 hours a day, inserting one end of the rubber band into the miniscrew and the other end into the pre-welded hook into the button. The miniscrew is placed perpendicular to the occlusal plane so as not to create discomfort when inserting the elastic (57,58).

When TADs continuously provide the right amount of extrusive force in the proper direction without worrying about anchoring loss, the impacted canine will progress toward the dental arch as the other teeth are independently levelled and aligned at the same time. The regional acceleratory phenomena that develop as a result of mucosal retraction and bone removal can be advantageously used to apply orthodontic force as soon as possible after exposure surgery (82).

For the treatment of palatally impacted canine teeth, Heravi et al. proposed this unique procedure with a distinct appliance design that used two bracket-type mini-screws. The mini-screws were inserted between the first and second premolars as well as between the second premolar and the M1. The two bracket-style miniscrew slots on the rectangular TMA wire were used to create a cantilever spring, which was then ligated with ligature wire (83).

Noroozian et al., in three patients, after surgical exposure of the palatally impacted canine, for the traction phase of the tooth applied a cantilever anchored to two miniscrews inserted in the palate, before starting orthodontic treatment. The cantilever is made of 0.017-0.025-inch stainless steel wire with a hook or helix in the anterior area to ligate the ligature wire and a U-loop in the middle to change the load's direction (56). This disengages the root of the canine from that of the lateral avoiding resorption of the root of the lateral, the patient also has an aesthetic advantage because there is permanence of the milk tooth in place, at least at first. The treatment also lasts much less overall and the arch form is not changed. Fixed orthodontics begins at the moment when the canine cusp emerges from the palatal mucosa and aims to bring the tooth back into the arch (56).

Another therapeutic option for palatally included canines involves a hybrid approach that includes sectional wires (0.017 × 0.025 TMA), miniscrews (1.3 mm wide and 10 mm long) and aligners. Both a first-canine approach and a first-stage alignment and subsequent traction of the canine have proven to be equally valid techniques: the choice of one appurtenance over the other is dictated primarily by the space in the arch at the time of treatment initiation: a lack of space requires a first-stage opening and a simultaneous or subsequent traction phase (55).

Bellot-Arcis et al. in a paper published in 2021 described a multidisciplinary, non-surgical orthodontic treatment of an adult patient with Class III skeletal malocclusion, palatally impacted canine, treated with fixed appliances and skeletal anchorage (60). To straighten the mandibular molars, distalise the entire mandibular arch and avoid an excessive inclination of the maxillary incisors to improve dentofacial aesthetics, two miniscrews were placed in the retromolar area.

The treatment results were very satisfactory and remained stable after a reasonable retention period. Two TADs were placed distal to the mandibular M2. Distal traction was performed with elastic chains from the minivits. After distalisation of the mandibular arch, achieved by the use of miniscrews, the patient's malocclusion improved significantly within a reasonable treatment time (60).

Chang et al. describe a case of a 12-year-old boy with bilaterally included maxillary canines. Two miniscrews were used to space the arch and distalise the maxillary dentition. The treatment lasted 25 months. The maxillary canines were moved away from the short roots of the incisors by the miniscrews, and further root resorption was avoided (61).

Galluccio et al. present in their article for canine disinclusion including the subperiosteal tunnel access technique with vertical incision (VISTA) This technique shows good performance regarding the direction of forces and periodontal condition of the canine when erupted; it is usually performed using an elastic chain connected to a TADs in the posterior area (62).

Migliorati et al. compared the efficiency of two different anchorage systems to disinclude maxillary canines using a CBCT. Two anchorage systems, TADs and palatal anchorage, were used. The study was carried out on 22 patients and no major differences in results were observed with the two methods (63). This review has several limitations:

1. Heterogeneous study designs: the included studies vary in design, such as case-control, observational, retrospective, and prospective studies. Combining data from different study designs may introduce heterogeneity and affect the validity of the review's conclusions.
2. Limited sample sizes: some of the included studies have small sample sizes, which could limit the statistical power and generalizability of the findings.
3. Lack of quality assessment: the review does not mention whether a quality assessment of the included studies was conducted. Evaluating the methodological quality of the studies is essential to assess the overall reliability of the evidence.
4. Limited scope of analysis: the review mainly focuses on muscle activity following mandibular condylar fractures, but it does not discuss other potential outcomes or complications related to these fractures, such as pain, joint function, or psychosocial impact. A more comprehensive analysis of the implications of these fractures would provide a more robust understanding of the topic.
5. No meta-analysis: while the review mentions "qualitative analysis," it does not provide any meta-analysis or systematic synthesis of the findings. A meta-analysis, if possible, could help in pooling the results from multiple studies to draw more robust conclusions.

## CONCLUSIONS

In our research, it has emerged that the resolution of dental inclusions can be achieved both with and without the use of TADs, resulting in a satisfactory and stable outcome over time. In general, the use of skeletal anchorage through TADs in orthodontic treatment has expanded treatment possibilities and improved efficiency. The utilization of TADs offers various advantages, including a wider range of action, faster tooth movement, and increased stability and accessibility. Several treatment protocols have been developed, including the use of TADs, cantilevers, elastic chains and coil springs to provide continuous extrusive force in the correct direction. In conclusion, dental inclusion is a significant issue in dentistry and with the progress of techniques and instruments it is possible to resolve dental inclusion cases more safely and predictably with accurate and reliable therapeutic protocols. Further research and advancements in the field of orthodontics will continue to enhance the management of dental inclusions, offering better outcomes to individuals with this condition.

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## REFERENCES


1. Cozza P, Mucedero M, Ricchiuti MR, Baccetti T. *Il Canino Superiore Incluso. Diagnosi E Terapia Basate Sull'evidenza Scientifica*. Edizioni Martina; 2010.
2. Inchingolo F, Tatullo M, Abenavoli FM, et al. Non-syndromic multiple supernumerary teeth in a family unit with a normal karyotype: case report. *International Journal of Medical Sciences*. 2010;7:378-384. doi:https://doi.org/10.7150/ijms.7.378
3. Peck S, Peck L, Kataja M. The palatally displaced canine as a dental anomaly of genetic origin. *The Angle Orthodontist*. 1994;64(4):249-256. doi:https://doi.org/10.1043/0003-3219(1994)064%3C0249:WNID%3E2.0.CO;2
4. Baccetti T. Risk Indicators and Interceptive Treatment Alternatives for Palatally Displaced Canines. *Seminars in Orthodontics*. 2010;16(3):186-192. doi:https://doi.org/10.1053/j.sodo.2010.05.004
5. Matteo Chiapasco. *Manuale Illustrato Di Chirurgia Orale - IV Edizione*. Edra; 2020.
6. Litsas G. A Review of Early Displaced Maxillary Canines: Etiology, Diagnosis and Interceptive Treatment. *The Open Dentistry Journal*. 2011;5(1):39-47. doi:https://doi.org/10.2174/1874210601105010039
7. Minervini G, Franco R, Minervini G, Fiorillo L, Cervino G, Cicciù M. Prevalence of temporomandibular disorders (TMD) in pregnancy: A systematic review with meta-analysis. *J Oral Rehabil*. 2023;50(7):627-634. doi:https://doi.org/10.1111/joor.13458
8. Minervini G, Franco R, Minervini G, Ronsivalle V, Shapira IL, Cicciù M. Prevalence of temporomandibular disorders in subjects affected by Parkinson disease: A systematic review and metanalysis. *Journal of Oral Rehabilitation*. 2023;50(9):877-885. doi:https://doi.org/10.1111/joor.13496
9. Pasini M, Giuca MR, Ligori S, et al. Association between Anatomical Variations and Maxillary Canine Impaction: A Retrospective Study in Orthodontics. *Applied Sciences*. 2020;10(16):5638. doi:https://doi.org/10.3390/app10165638
10. Ericson S, Kurol J r. Early treatment of palatally erupting maxillary canines by extraction of the primary canines. *The European Journal of Orthodontics*. 1988;10(1):283-295. doi:https://doi.org/10.1093/ejo/10.1.283
11. Mucedero M, Franchi L, Maria Rosaria Ricchiuti, Cozza P. Association between mesially displaced maxillary first premolars and early displaced maxillary canines. *Eur J Paediatr Dent*. 2015;16(1):45-50.
12. Crincoli V, Anelli MG, Quercia E, Piancino MG, Di Comite M. Temporomandibular Disorders and Oral Features in Early Rheumatoid Arthritis Patients: An Observational Study. *International Journal of Medical Sciences*. 2019;16(2):253-263. doi:https://doi.org/10.7150/ijms.28361
13. Crincoli V, Di Comite M, Guerrieri M, et al. Orofacial Manifestations and Temporomandibular Disorders of Sjögren Syndrome: An Observational Study. *International Journal of Medical Sciences*. 2018;15(5):475-483. doi:https://doi.org/10.7150/ijms.23044
14. Crincoli V, Scivetti M, Di Bisceglie MB, Pilolli GP, Favia G. Unusual case of adverse reaction in the use of sodium hypochlorite during endodontic treatment: a case report. *Quintessence International (Berlin, Germany: 1985)*. 2008;39(2):e70-73.
15. Crincoli V, Ballini A, Fatone L, Di Bisceglie MB, Nardi GM, Grassi FR. Cytokine genotype distribution in patients with periodontal disease and rheumatoid arthritis or diabetes mellitus. *Journal of Biological Regulators and Homeostatic Agents*. 2016;30(3):863-866.
16. Favia G, Tempesta A, Limongelli L, Crincoli V, Adriano Piattelli. Metastatic Breast Cancer in Medication-Related Osteonecrosis Around Mandibular Implants. *American Journal of Case Reports*. 2015;16:621-626. doi:https://doi.org/10.12659/ajcr.894162
17. Moyers RE. *Handbook of Orthodontics*. Year Book Medical Publishers, Incorporated; 1988.
18. Kuftinec MM, Shapira Y. The impacted maxillary canine: I. Review of concepts. *ASDC J Dent Child* 1995;62(5):317-324.
19. Jacoby H. The etiology of maxillary canine impactions. *American Journal of Orthodontics*. 1983;84(2):125-132. doi:https://doi.org/10.1016/0002-9416(83)90176-8

20. Inchingolo AD, Carpentiere V, Piras F, et al. Orthodontic Surgical Treatment of Impacted Mandibular Canines: Systematic Review and Case Report. *Applied sciences*. 2022;12(16):8008-8008. doi:https://doi.org/10.3390/app12168008
21. Power SM, Short MBE. An Investigation into the Response of Palatally Displaced Canines to the Removal of Deciduous Canines and an Assessment of Factors Contributing to Favourable Eruption. *British Journal of Orthodontics*. 1993;20(3):215-223. doi:https://doi.org/10.1179/bjo.20.3.215
22. Sacerdoti R, Baccetti T. Dentoskeletal features associated with unilateral or bilateral palatal displacement of maxillary canines. *The Angle Orthodontist*. 2004;74(6):725-732. doi:https://doi.org/10.1043/0003-3219(2004)074%3C0725:DFAWUO%3E2.0.CO;2
23. Lorente C, Perez-Vela M, Lorente P, Lorente T. Miniscrew-supported pole technique: Surgical-orthodontic approach for impacted or retained second molars in adolescents. *International Orthodontics*. 2021;19(1):147-158. doi:https://doi.org/10.1016/j.ortho.2020.10.003
24. Patano A, Malcangi G, De Santis M, et al. Conservative Treatment of Dental Non-Carious Cervical Lesions: A Scoping Review. *Biomedicines*. 2023;11(6):1530-1530. doi:https://doi.org/10.3390/biomedicines11061530
25. Malcangi G, Patano A, Morolla R, et al. Analysis of Dental Enamel Remineralization: A Systematic Review of Technique Comparisons. *Bioengineering*. 2023;10(4):472. doi:https://doi.org/10.3390/bioengineering10040472
26. Inchingolo AM, Fatone MC, Malcangi G, et al. Modifiable Risk Factors of Non-Syndromic Orofacial Clefts: A Systematic Review. *Children*. 2022;9(12):1846. doi:https://doi.org/10.3390/children9121846
27. Quinzi V, Saccomanno S, Manenti RJ, Giancaspro S, Coceani Paskay L, Marzo G. Efficacy of Rapid Maxillary Expansion with or without Previous Adenotonsillectomy for Pediatric Obstructive Sleep Apnea Syndrome Based on Polysomnographic Data: A Systematic Review and Meta-Analysis. *Applied Sciences*. 2020;10(18):6485. doi:https://doi.org/10.3390/app10186485
28. Lindauer SJ, Rubenstein LK, Hang WM, Andersen WC, Isaacson RJ. Canine Impaction Identified Early with Panoramic Radiographs. *The Journal of the American Dental Association*. 1992;123(3):91-97. doi:https://doi.org/10.14219/jada.archive.1992.0069
29. Mummolo S, Nota A, Marchetti E, Padricelli G, Marzo G. The 3D Tele Motion Tracking for the Orthodontic Facial Analysis. *BioMed Research International*. 2016;2016:1-6. doi:https://doi.org/10.1155/2016/4932136
30. Inchingolo F, Tatullo M, Abenavoli FM, et al. Surgical Treatment of Depressed Scar: A Simple Technique. *International Journal of Medical Sciences*. 2011;8(5):377-379. doi:https://doi.org/10.7150/ijms.8.377
31. Reddy LKV, Madithati P, Narapureddy BR, et al. Perception about Health Applications (Apps) in Smartphones towards Telemedicine during COVID-19: A Cross-Sectional Study. *Journal of Personalized Medicine*. 2022;12(11):1920. doi:https://doi.org/10.3390/jpm12111920
32. Rathi S, Chaturvedi S, Abdullah S, et al. Clinical Trial to Assess Physiology and Activity of Masticatory Muscles of Complete Denture Wearer Following Vitamin D Intervention. *Medicina-lithuania*. 2023;59(2):410-410. doi:https://doi.org/10.3390/medicina59020410
33. Malcangi G, Inchingolo AD, Patano A, et al. Impacted Central Incisors in the Upper Jaw in an Adolescent Patient: Orthodontic-Surgical Treatment—A Case Report. *Applied Sciences*. 2022;12(5):2657. doi:https://doi.org/10.3390/app12052657
34. Ericson S, Kurol J. Radiographlc assessment of maxillary canine eruption in children with clinical signs of eruption disturbance. *The European Journal of Orthodontics*. 1986;8(3):133-140. doi:https://doi.org/10.1093/ejo/8.3.133
35. Ericson S, Kurol J. Radiographic examination of ectopically erupting maxillary canines. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1987;91(6):483-492. doi:https://doi.org/10.1016/0889-5406(87)90005-9
36. Inchingolo AM, Malcangi G, Costa S, et al. Tooth Complications after Orthodontic Miniscrews Insertion. *International Journal of Environmental Research and Public Health*. 2023;20(2):1562-1562. doi:https://doi.org/10.3390/ijerph20021562
37. Altieri F, Guarnieri R, Mezio M, et al. Uprighting Impacted Mandibular Second Molar Using a Skeletal Anchorage: A Case Report. *Dentistry Journal*. 2020;8(4):129. doi:https://doi.org/10.3390/dj8040129
38. Mah SJ, Won PJ, Nam JH, Kim EC, Kang YG. Uprighting mesially impacted mandibular molars with 2 miniscrews. *American*

*Journal of Orthodontics and Dentofacial Orthopedics*. 2015;148(5):849-861. doi:https://doi.org/10.1016/j.ajodo.2015.07.027

39. Jing Z, Wu Y, Jiang W, et al. Factors Affecting the Clinical Success Rate of Miniscrew Implants for Orthodontic Treatment. *The International Journal of Oral & Maxillofacial Implants*. 2016;31(4):835-841. doi:https://doi.org/10.11607/jomi.4197
40. Cheng SJ, Tseng IY, Lee JJ, Kok SH. A prospective study of the risk factors associated with failure of mini-implants used for orthodontic anchorage. *The International Journal of Oral & Maxillofacial Implants*. 2004;19(1):100-106.
41. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. *American Journal of Orthodontics and Dentofacial Orthopedics: Official Publication of the American Association of Orthodontists, Its Constituent Societies, and the American Board of Orthodontics*. 2003;124(4):373-378. doi:https://doi.org/10.1016/s0889-5406(03)00565-1
42. Park H. Clinical study on success rate of microscrew implants for orthodontic anchorage. *Korean Journal of Orthodontics*. 2003;33(3):151-156. http://www.ekjo.org/journal/view.html?doi=
43. Vermeşan D, Inchingolo F, Pătrașcu JM, et al. Anterior cruciate ligament reconstruction and determination of tunnel size and graft obliquity. *Eur Rev Med Pharmacol Sci*. 2015;19(3):357-364.
44. Inchingolo F, Tatullo M, Abenavoli FM, et al. Non-Hodgkin lymphoma affecting the tongue: unusual intra-oral location. *Head & Neck Oncology*. 2011;3(1). doi:https://doi.org/10.1186/1758-3284-3-1
45. Cantore S, Mirgaldi R, Ballini A, et al. Cytokine Gene Polymorphisms Associate with Microbiogical Agents in Periodontal Disease: Our Experience. *International Journal of Medical Sciences*. 2014;11(7):674-679. doi:https://doi.org/10.7150/ijms.6962
46. Inchingolo F, Tatullo M, Marrelli M, et al. Clinical trial with bromelain in third molar exodontia. *Eur Rev Med Pharmacol Sci*. 2010;14(9):771-774.
47. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ*. 2009;339(339):b2700-b2700. doi:https://doi.org/10.1136/bmj.b2700
48. Lorente C, Lorente P, Perez-Vela M, Esquinas C, Lorente T. Management of Deeply Impacted Molars with the Miniscrew-Supported Pole Technique. *Journal of clinical orthodontics*. 2018;52(11):589-597.
49. Morita Y, Koga Y, Nguyen TA, Yoshida N. Biomechanical considerations for uprighting impacted mandibular molars. *Korean Journal of Orthodontics*. 2020;50(4):268-277. doi:https://doi.org/10.4041/kjod.2020.50.4.268
50. Rodriguez Y Baena R, Lupi MS, Ceriana G, Sfondrini MF, Scribante A. Extrusion of severely impacted mandibular first molar using partial orthodontics and temporary anchorage miniscrews. *European Journal of Paediatric Dentistry*. 2016;17(4):310-314.
51. Lorente C, Lorente P, Perez-Vela M, Esquinas C, Lorente T. Treatment of impacted or retained second molars with the miniscrew-supported pole technique: a prospective follow-up study. *Progress in Orthodontics*. 2022;23(1). doi:https://doi.org/10.1186/s40510-022-00432-5
52. Zhao S, Wang Y, Yang X, et al. Extraction of impacted mandibular third molars in close proximity to the inferior alveolar canal with coronectomy-miniscrew traction to avoid nerve injury. *Clinical Oral Investigations*. 2023;27(8):4279-4288. doi:https://doi.org/10.1007/s00784-023-05044-9
53. Cortes ARG, No-Cortes J, Cavalcanti MGP, Arita ES. An alternative approach to extruding a vertically impacted lower third molar using an orthodontic miniscrew: A case report with cone-beam CT follow-up. *Imaging Science in Dentistry*. 2014;44(2):171. doi:https://doi.org/10.5624/isd.2014.44.2.171
54. Baik UB, Kook YA, Bayome M, Park JU, Park JH. Vertical eruption patterns of impacted mandibular third molars after the mesialization of second molars using miniscrews. *The Angle Orthodontist*. 2014;86(4):565-570. doi:https://doi.org/10.2319/061415-399.1
55. Greco M, Machoy M. Impacted Canine Management Using Aligners Supported by Orthodontic Temporary Anchorage Devices. *International Journal of Environmental Research and Public Health*. 2022;20(1):131. doi:https://doi.org/10.3390/ijerph20010131
56. Noroozian M, Mohammadi M, Farzin Heravi, Hooman Shafaee. Introducing a User-Friendly Technique for Treatment of Palatally-Impacted Canines with the Aid of Temporary Anchorage Devices. *DOAJ (DOAJ: Directory of Open Access Journals)*.

2022;23(4):511-519. doi:https://doi.org/10.30476/dentjods.2022.91156.1557

57. Venugopal A. Interarch traction for impacted canines. *APOS Trends in Orthodontics*. 2020;10:60-61. doi:https://doi.org/10.25259/apos_133_2019
58. Venugopal A, Vaid NR. Interarch Traction Strategy for Palatal Cuspid Impactions. *The journal of contemporary dental practice*. 2020;21(12):1408-1411. doi:https://doi.org/10.5005/jp-journals-10024-2972
59. Jung S, Lee JH, Huh J, Park W. Orthodontic Extrusion of Mandibular Third Molar With a Miniscrew and Cross-Arch Elastic. *Journal of Oral and Maxillofacial Surgery*. 2021;79. doi:https://doi.org/10.1016/j.joms.2021.01.036
60. Bellot-Arcís C, García-Sanz V, Paredes-Gallardo V. Nonsurgical treatment of an adult with skeletal Class III malocclusion, anterior crossbite, and an impacted canine. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2021;159. doi:https://doi.org/10.1016/j.ajodo.2020.01.023
61. Chang N, Jae Hyun Park, Lee MY, et al. Orthodontic Treatment of Maxillary Incisors with Severe Root Resorption Caused by Bilateral Canine Impaction in a Class II Division 1 Patient. *Journal of Clinical Pediatric Dentistry*. 2016;40(2):161-168. doi:https://doi.org/10.17796/1053-4628-40.2.161
62. Galluccio G, Impellizzeri A, Pietrantoni A, De Stefano A, La Monaca G, Pippi R. The VISTA Approach in Canine Disimpaction. *Methods and Protocols*. 2021;4(3):57. doi:https://doi.org/10.3390/mps4030057
63. Migliorati M, Cevidanes L, Sinfonico G, et al. Three dimensional movement analysis of maxillary impacted canine using TADs: a pilot study. *Head & Face Medicine*. 2021;17(1). doi:https://doi.org/10.1186/s13005-020-00252-0
64. Agarwal S, Gupta S, Chugh VK, Jain E, Valiathan A, Nanda R. Interdisciplinary treatment of a periodontally compromised adult patient with multiple missing posterior teeth. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2014;145(2):238-248. doi:https://doi.org/10.1016/j.ajodo.2013.03.027
65. Ricardo Fidos Horliana, Carolina A, Alexandre, Guillin E, Abrão J. Dental Extrusion with Orthodontic Miniscrew Anchorage: A Case Report Describing a Modified Method. *Case Reports in Dentistry*. 2015;2015:1-6. doi:https://doi.org/10.1155/2015/909314
66. Tolga Topçuoğlu, Ali Altuğ Bıçakçı, Mustafa Cihat Avunduk, Deniz Z. Evaluation of the Effects of Different Surface Configurations on Stability of Miniscrews. *The Scientific World Journal*. 2013;2013:1-7. doi:https://doi.org/10.1155/2013/396091
67. Jia H, Zhuang L, Zhang N, Bian Y, Li S. Comparison of skeletal maxillary transverse deficiency treated by microimplant-assisted rapid palatal expansion and tooth-borne expansion during the post-pubertal growth spurt stage: *The Angle Orthodontist*. 2020;91(1):36-45. doi:https://doi.org/10.2319/041920-332.1
68. Tecco S, Mummolo S, Marchetti E, et al. sEMG activity of masticatory, neck, and trunk muscles during the treatment of scoliosis with functional braces. A longitudinal controlled study. *Journal of Electromyography and Kinesiology*. 2011;21(6):885-892. doi:https://doi.org/10.1016/j.jelekin.2011.08.004
69. Bernardi S, Mummolo S, Tecco S, Continenza MA, Marzo G. Histological Characterization of Sacco's Concentrated Growth Factors Membrane. *International Journal of Morphology*. 2017;35(1):114-119. doi:https://doi.org/10.4067/s0717-95022017000100019
70. Vedtofte H, Andreasen JO, Kjær I. Arrested eruption of the permanent lower second molar. *Eur J Orthod*. 1999;21(1):31-40. doi:https://doi.org/10.1093/ejo/21.1.31
71. Poggio PM, Incorvati C, Velo S, Carano A. "Safe Zones": A Guide for Miniscrew Positioning in the Maxillary and Mandibular Arch. *The Angle Orthodontist*. 2006;76(2):191-197. doi:https://doi.org/10.1043/0003-3219(2006)076%5B0191:SZAGFM%5D2.0.CO;2
72. Bereket C, Çakır-Özkan N, Şener İ, Kara İ, Aktan AM, AriciN. Retrospective analysis of impacted first and second permanent molars in the Turkish population: A multicenter study. *Medicina Oral Patologia Oral Y Cirugia Bucal*. 2011;16:e874-e878. doi:https://doi.org/10.4317/medoral.17094
73. Aydin U, Yilmaz HH, Yildirim D. Incidence of canine impaction and transmigration in a patient population. *Dento Maxillo Facial Radiology*. 2004;33(3):164-169. doi:https://doi.org/10.1259/dmfr/15470658
74. Vasoglou G, Lyros I, Patatou A, Vasoglou M. Orthodontic Treatment of Palatally Impacted Maxillary Canines with the Use of a Digitally Designed and 3D-Printed Metal Device. *Dent J*. 2023;11(4):102-102. doi:https://doi.org/10.3390/dj11040102

75. Lochmatter D, Steineck M, Brauchli L. Influence of material choice on the force delivery of bimaxillary tooth positioners on canine malpositions. *Journal of Orofacial Orthopedics / Fortschritte der Kieferorthopädie*. 2012;73(2):104-115. doi:https://doi.org/10.1007/s00056-011-0067-7
76. Bowman Sj, Carano A. The Kilroy Spring for impacted teeth. *J Clin Orthod*. 2003;37(12):683-688.
77. Fleming PS, Sharma PK, DiBiase AT. How to…mechanically erupt a palatal canine. *Journal of Orthodontics*. 2010;37(4):262-271. doi:https://doi.org/10.1179/14653121043200
78. Vaid NR, Doshi V, Kulkarni P, Meghna Vandekar. A traction arch for impacted mandibular canines and premolars. *J Clin Orthod JCO*. 2014;48(3):191-195.
79. Counihan K, Al-Awadhi E, Butler J. Guidelines for the assessment of the impacted maxillary canine. *Dental Update*. 2013;40(9):770-777. doi:https://doi.org/10.12968/denu.2013.40.9.770
80. Clark JD, Kerr WJ, Davis MH. CASES--clinical audit; scenarios for evaluation and study. *British Dental Journal*. 1997;183(3):108-111. doi:https://doi.org/10.1038/sj.bdj.4809434
81. Da Silva AC, Capistano A, de Almeida-Pedrin RR, de Almeida Cardoso M, de Castro Ferreira Conti AC, Capelozza Filho L. Root length and alveolar bone level of impacted canines and adjacent teeth after orthodontic traction: a long-term evaluation. *Journal of Applied Oral Science*. 2017;25(1):75-81. doi:https://doi.org/10.1590/1678-77572016-0133
82. Ferguson DJ, Rossais DA, Wilcko MT, Makki L, Stapelberg R. Forced-eruption time for palatally impacted canines treated with and without ostectomy-decortication technique. *The Angle Orthodontist*. 2019;89(5):697-704. doi:https://doi.org/10.2319/111418-809.1
83. Heravi F, Shafaee H, Forouzanfar A, Zarch SHH, Merati M. Forced eruption of palatally impacted canines using bracket-head miniscrews. *Journal of clinical orthodontics: JCO*. 2014;48(9):576-580.