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Review

Different approaches and effectiveness in orthodontic traction of impacted canines: An integrative systematic review

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Abstract: Canines have a fundamental role in the dental arch, both aesthetically and functionally. Apart from the third molars, maxillary canines are the most frequently impacted teeth. Orthodontic traction of an impacted canine is one of the most appropriate approaches when there is a good prognosis, in growing patients and without a serious lack of space in the arch. This systematic review aims to describe the different approaches used in orthodontic traction of impacted canines and evaluate their effectiveness. PRISMA guidelines were used to perform a bibliographic search on the referenced platform PubMed. Articles published between 2014 and May 2024 were selected. Nine articles were included, and another five were added by manual search. The most studied methods were the transpalatal arch, the mini-implant, and the cantilever spring, which prove to be quite effective. Aligners, when combined with auxiliary methods, have been demonstrated to be a viable and effective alternative to conventional techniques. However, further research is required. Despite there being no consensus among authors as to which is the most effective method, choosing the correct traction approach through an accurate diagnosis and treatment planning is crucial for the successful orthodontic treatment of impacted canines.

Keywords: cuspid; impacted tooth; traction; orthodontics; orthodontic extrusion

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Introduction

The maxillary canines are extremely important in the dental arch and essential for good aesthetics, function, and stability [1]. Currently, there is still no consensus on the etiology of maxillary canine impaction but it is known that several factors can influence it. The prevalence of impacted maxillary canines (IMC) in the population is 1-3% [2]. Excluding the third molars, these are the most frequently impacted teeth [3]. The impaction of maxillary canines is more likely to occur in women than men, and more often unilaterally than bilaterally [4,5]. According to Bishara *et al.*, the incidence of bilateral impact in patients with IMC is 8%. It is also known that, in two-thirds of the cases, the palatine zone is affected, and it involves the vestibular zone in only one-third. The percentage of the mandibular canine's impact is significantly lower when compared with that of maxillary canines [4]. A good diagnosis must be made through a clinical and radiographic assessment of the impacted canines (IC). The location of the IMC should be assessed two- or three-dimensionally, and the difficulty of orthodontic traction should be realized [6,7]. The three-dimensional (3D) location of IMC is essential for clinical practice, assessing the presence, inclination, buccal and palatal positions, bone coverage, root resorption of adjacent teeth, adjacent teeth condition, local anatomy, and dental development stages. Cone beam computed tomography (CBCT) is currently considered the best method for diagnosing and planning impacted tooth treatment [8,9]. Several approaches can be taken in the case of IC. The choice of treatment may depend on various factors, such as the patient's age, the stage of dental development, the position of the IC, the presence of root resorption in adjacent teeth, and the patient's acceptance of the treatment [10]. Orthodontic traction is optimal for IC with favorable prognosis, in growing patients, and when there is no significant lack of space in the dental arch. To realign the tooth within the arch, a surgical exposure of the

impacted tooth is required, and orthodontic traction may or may not be necessary [11]. Surgical exposure followed by traction requires a multidisciplinary approach involving oral and maxillofacial surgeons, orthodontists, and periodontists [12]. Thus, this systematic review describes the different methods used in orthodontic traction of IC and evaluates their effectiveness.

Materials and Methods

Review guidelines

This systematic review was elaborated following the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) 2020 guidelines. The study protocol was registered in the PROSPERO database (CRD42024547419).

Eligibility criteria

The Population, Intervention, Comparison, Outcomes, and Study design (PICOS) were defined, as presented in Table 1. Therefore, the PICOS strategy was used to define the following research questions: "What are the most commonly used methods for orthodontic traction of impacted canines? Are they effective?". In this sense, the eligibility criteria for the studies to be included were defined.

Table 1. PICOS strategy.

Population	Patients with impacted canines
Intervention	Orthodontic traction of impacted canines
Comparison	Compare the different methods used in orthodontic traction
Outcomes	Effectiveness of repositioning the canine correctly in the dental arch using different methods
Study design	Retrospective studies, cross-sectional studies, controlled clinical trials (randomized or not) and case reports

The inclusion criteria were: articles published between 2014 and May 2024; studies performed in humans; retrospective, cross-sectional studies, controlled clinical trials (randomized or not), and case reports. The exclusion criteria were: articles whose abstracts did not address the topic under study; articles that did not provide relevant information after detailed reading; systematic review articles, theses, and dissertations.

Search strategy

The bibliographic research was carried out in the PubMed database. Articles published between 2014 and May 2024 were selected. The keywords and MeSH terms employed, as well as the data related to the search strategy, are shown in Table 2.

Table 2. Search strategy.

Databases	Advanced search	Total articles	Selected articles
PubMed	((“tooth, impacted” OR “impacted tooth”) AND (cuspid) AND (orthodontics) AND (traction OR orthodontic extrusion))	104	9

Selection of articles and data collection

Using the search terms previously exposed, an advanced search was performed. To ascertain whether the titles and abstracts of the potentially relevant articles met the purpose of the study, a preliminary analysis was conducted. The clinical studies that met the inclusion criteria were fully analyzed, and their eligibility was evaluated. In addition, a manual search was conducted in the bibliographies of the included studies to identify and retrieve articles that had not been found through the electronic search. Finally, the relevant data were collected and organized in Table 3.

Quality assessment of data

The ROBINS-I tool was used to assess the methodological quality of the retrospective studies, cross-sectional studies, and randomized and non-randomized clinical trials. The Joanna Briggs Institute (JBI) critical appraisal checklist was used to assess the quality of the case reports. Two authors (JPC and RA) independently evaluated the quality of the selected articles based on seven bias domains: confounding,

selection of participants, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, selection of the reported results, and overall bias.

Studies [6,13,14] and [15] had a moderate risk of bias. Studies [16] and [17] were considered to have a serious risk of bias (Table 4). All the case reports were considered to have a minimal risk of bias, and they were all included (Table 5).

Results

Selection of articles

The bibliographic search identified a total of 104 articles. Titles and abstracts were analyzed and 30 articles were selected for full reading. 26 articles were excluded because they did not contain relevant information. The 30 articles were analyzed in full, and nine were chosen and included in this project. Five articles were also included through a manual search; two were included to update knowledge about orthodontic traction with aligners, and the other three were considered relevant. Finally, 14 studies were included, as demonstrated in Figure 1.

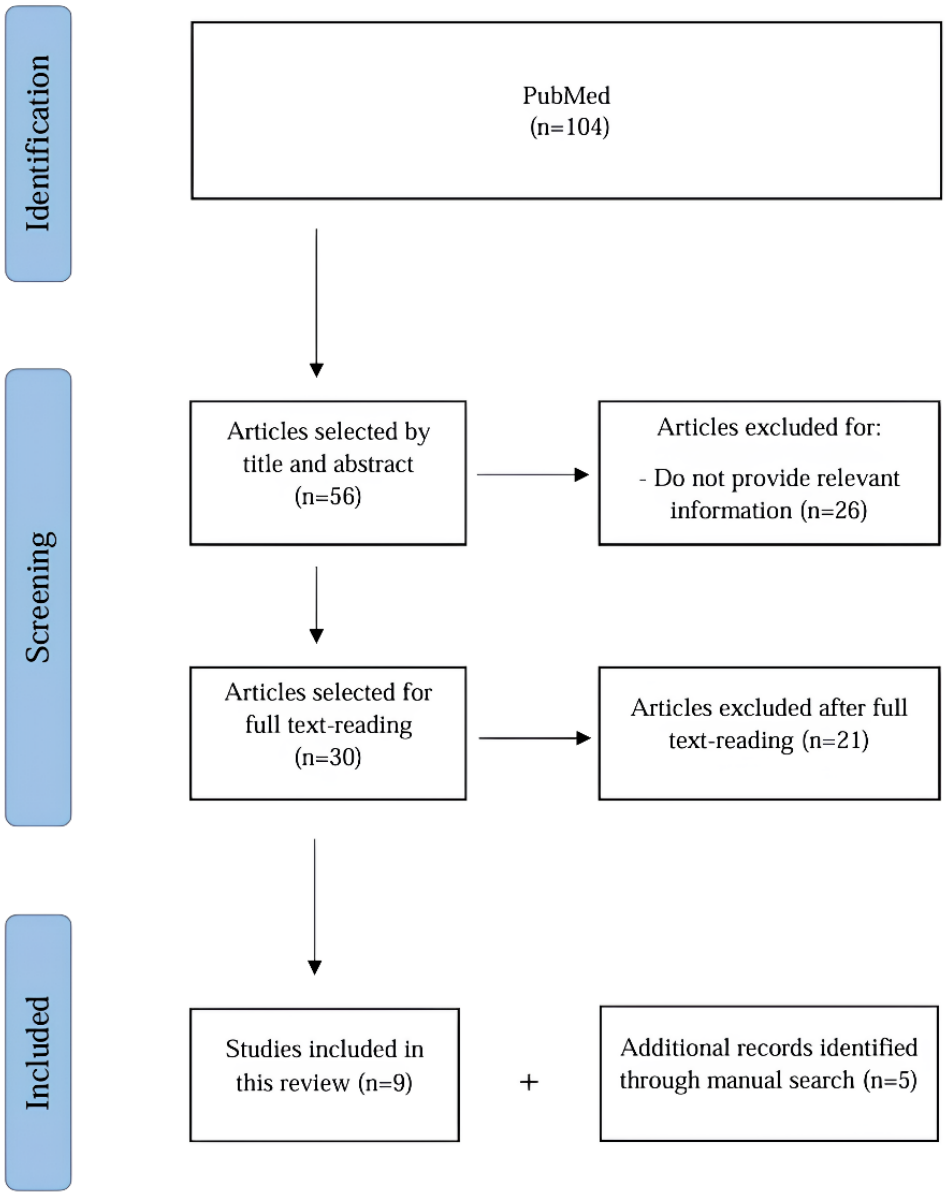

Figure 1. Flow diagram of the search strategy used in this study.

Table 3. Data and outcomes from articles.

Author and year of the publication	Study Design	Goals	Population	Intervention	Outcomes
Migliorati M *et al.* (2021) [13]	Randomized clinical trial	Compare the efficiency of two anchorage systems to disinclude IMC with CBCT evaluation	TPA-group (*n* = 11) TAD-group (*n* = 11)	• A CBCT was performed before starting treatment and approximately 3 months after starting traction • The TPA-group received a transpalatal arch as an anchorage device • The TAD-group received a mini-implant as an anchorage device	• Apex root movement: 0.44-0.84 mm/month • Movement of the canine tip: 1.08-1.96 mm/month • TADs did not allow faster traction of the canine than anchorage with TPA
Potrubacz MI *et al*. (2018) [14]	Retrospective study	Evaluate the time required for orthodontic traction of palatally IMC	*n* = 22 (30 IMC)	• A cantilever was used and was soldered five times around the TPA	• The cantilever/TPA was efficient and predictable • A shorter treatment time was observed in male patients • The younger the patient, the shorter the IMC extrusion time, regardless of its position
Stabryła J *et al*. (2021) [16]	Retrospective study	Compare different treatment methods and their outcomes for impacted maxillary and mandibular canines	*n* = 102 (82 IMC and 36 IMandC)	• Orthodontic traction was performed in 65 IMC and 8 IMandC • 4 different methods were used: Transpalatal Bar, Fixed Appliance, Miniscrew and Removable Appliance	• The traction was effective in 95% of IMC and 100% of IMandC
Heravi F *et al*. (2016) [17]	Non-randomized clinical trial	Evaluate the movement of IC away from the roots of neighboring teeth before full-mouth bracket placement	*n* = 26 (34 palatally IMC)	• In the palatal region of each IMC, two miniscrews were inserted • A bracket was bonded to the canine, and a 50-*g* force was delivered to it via a palatal cantilever spring	• Clinical success rate: 100%; TADs survival rate: 94,7% • TADs allowed a more controlled movement of the IMC • Disimpacting palatally IMC before aligning the teeth may reduce root resorption
Baruah DJ *et al*. (2021) [7]	Case report	Position the IC in the arch with minimal impact on the supporting periodontium	*n* = 1	• Bond of a Begg's bracket and application of traction force by the mini-implant • Application of a vertically directed force from the Nance button hook • Extrusion of the canine using a cantilever spring	• The mini-implant and the modified Nance button redirect the IMC from a horizontal position to a more vertical position • The cantilever spring allowed constant forces to be applied
Singh S *et al*. (2022) [18]	Case reports	Exhibit the different methods used for orthodontic-assisted	*n* = 6 (6 IMC)	6 methods were used: • Molar supported cantilever spring • TAD supported cantilever spring • Inter-maxillary elastic • Kilroy spring	The force vector, angulation, and position of the IMC in relation to the surrounding structures must be carefully analyzed to

		eruption of IMC		• Modified Ballista spring • Piggy archwire	choose the ideal traction method
Yang JS *et al*. (2022) [6]	Cross-sectional study	Classify the radiographical characteristics of IMC and investigate their correlation with the traction duration	*n* = 74 (87 IMC)	• Surgical exposure and traction were performed in the IMC • A CBCT exam and a panoramic radiograph were performed before surgical exposure	• The probability of palatal impaction and resorption of the adjacent root was high when the IMCs were located mesially • The distance from the occlusal plane to the IMCs showed the strongest positive correlation with traction duration
Venugopal A *et al*. (2020) [19]	Case report	To disimpact a palatally IMC using a novel, compliance-dependent technique	*n* = 1	• Intermaxillary elastics were hooked onto a miniscrew that was inserted in the opposite arch	• Treatment duration: 11 months • The patient reported some tongue interference and discomfort during the traction process
Mampieri G *et al*. (2021) [20]	Case report	Describe the treatment of IC combining aligners with a conventional forced eruption technique	*n* = 1	The treatment was divided into 3 phases: • Expansion of the arches • Surgical exposure and traction • Final positioning	• The release of forces occurs in all upper teeth, causing a slight intrusion • When using aligners, there is no problem with bracket detachment due to traction forces, unlike fixed appliances
Greco M *et al*. (2022) [21]	Case reports	Describe a sequence of treatment of IC with aligners supported by TADs	*n* = 2	• Case 1: Use of TAD and sectional wires for disimpaction and traction • Case 2: Mini-invasive laser gingivectomy followed by traction using direct anchorage by TAD and sectional wires	• Aligners with TADs and sectional wires represent a feasible alternative to conventional systems for treating IMC
Grenga C *et al*. (2021) [15]	Retrospective study	Evaluate the periodontal status of IMC treated by closed approach with ultrasonic surgery and orthodontic treatment	*n* = 17 (17 palatally IMC)	• An orthodontic button was placed on the canine and connected to the arch through metal ligatures	• Ultrasonic surgery and traction allow the alignment of an IMC without causing periodontal damage • Piezosurgery is an effective alternative to traditional surgery
Cruz RM *et al*. (2019) [22]	Case report	Present the treatment of a patient with a Class II division 2, malocclusion, deep bite, and prolonged retention of a primary upper canine	*n* = 1	• Developed specialized archwire with bypass and delta loop for traction • Implemented orthodontic brackets, flexible archwires, and intermaxillary elastics for corrective treatment	• The IMC was surgically exposed and tractioned for 5 months • Intermaxillary elastics require excellent patient collaboration

Pithon MM *et al*. (2022) [23]	Case report	Describe the treatment of a Class I malocclusion associated with traction of two IC	*n* = 1	• Intraoperative placement of the orthodontic device on the buccal surface of the IMC • 10 days later, a cantilever was installed for the traction of the IMC	• The canines were correctly repositioned in the arch • When the incisors show good periodontal health, projecting them to create space before IMC traction is a viable treatment option
Taffarel IP *et al*. (2018) [24]	Case report	Describe the successful clinical outcome of a patient with an IMC	*n* = 1	• Closed flap technique with orthodontic mesh bonded using ligature wire • Traction required silk thread, elastic chains, and ligature wire, while final alignment involved "L"-shaped multi-loop arches and double helix loops	• The IMC was successfully aligned, leveled and positioned in the occlusion line • The esthetic, functional and periodontal results remained stable in the retention phase

CBCT: cone beam computed tomography; IMandC: impacted mandibular canines; IMC: impacted maxillary canines; TAD: temporary anchorage device; TPA: transpalatal arch

Table 4. Risk of bias of observational studies, as assessed by the ROBINS-I quality assessment scale.

	Risk of bias domains						
Author and year of publication	**Bias due to confounding**	**Bias in selection of participants into the study**	**Bias in classification of interventions**	**Bias due to deviations from intended interventions**	**Bias due to missing data**	**Bias in measurement of outcomes**	**Bias in selection of the reported result**
Migliorati M *et al*. (2021) [13]	L	L	L	L	M	L	L
Potrubacz MI *et al*. (2018) [14]	L	L	L	L	L	M	L
Stabryła J *et al*. (2021) [16]	L	L	L	M	M	S	L
Heravi F *et al*. (2016) [17]	L	L	NI	L	L	S	L
Yang JS *et al*. (2022) [6]	L	L	L	L	L	M	L
Grenga C *et al*. (2021) [15]	L	L	L	L	L	M	L

L: low risk of bias; M: moderate risk of bias; S: serious risk of bias; NI: no information.

Table 5. Risk of bias of case reports, as assessed by the JBI critical appraisal checklist.

Checklist	**Baruah DJ *et al.* (2021)** [7]	**Singh S *et al.* (2022)** [18]	**Venugopal A *et al.* (2020)** [19]	**Mampieri G *et al.* (2021)** [20]	**Greco M *et al.* (2022)** [21]	**Cruz RM *et al.* (2019)** [22]	**Pithon MM *et al.* (2022)** [23]	**Taffarel IP *et al.* (2018)** [24]
1. Were patient's demographic characteristics clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Was the patient's history clearly described and presented as a timeline?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Was the current clinical condition of the patient on presentation clearly described?	Yes	No	No	Yes	No	Yes	Yes	Yes
4. Were diagnostic tests or assessment methods and the results clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Was(were) the intervention(s) or treatment procedure(s) clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Was the post-intervention clinical condition clearly described?	Yes	No	Yes	Yes	No	Yes	Yes	Yes
7. Were adverse events (harms) or unanticipated events identified and described?	No	Yes	Yes	Yes	Yes	No	Yes	No
8. Does the case report provide takeaway lessons?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Overall appraisal	Include	Include	Include	Include	Include	Include	Include	Include

Discussion

To date, to perform orthodontic traction on an impacted tooth, the appliance of choice was a fixed appliance with the possibility of adding a transpalatal arch (TPA). Fixed appliances have the advantage of being able to fix the traction element directly from the IC to the arch [21]. An obvious advantage of using aligners compared with fixed braces is the ease of dental hygiene during treatment, which can range from several months to years. This makes it easier to avoid certain complications such as dental caries, inflammatory periodontal diseases, and tooth decalcification [25,26]. However, treating IC with aligners can be challenging, especially without additional support like mini-implants [20]. The choice of traction method will depend mainly on the position of the IC and the need for anchorage [18].

In 2022, Greco *et al.* reported two cases of IC treatment using aligners with the aid of mini-implants. Aligners have no retaining elements, so the impacted tooth cannot be fixed to elements in the oral cavity.

Especially in cases of palatally IMC, aligners require the aid of mini-implants and often also that of archwires. Additionally, the authors considered that screening the canine before starting treatment with aligners will result in a shorter treatment time and fewer aligners used. However, space for the IMC must be fully available for this to be applied. Combining aligners with temporary anchorage devices (TADs) and sectional wires is a viable alternative to conventional traction systems for IC [21]. Migliorati *et al*. evaluated the effectiveness of two anchorage systems in the traction of IC: the TPA and mini-implants. An average canine tip movement of 1.08-1.96 mm/month and apical root movement of 0.44-0.84 mm/month were reported. There were no significant differences between the groups regarding apex movement and time interval. Canine tip movement was greater in the TPA-group, but the difference was also not considered significant. The TPA caused significant tipping on the first permanent molars. There was no evidence that indirect anchorage with TADs allowed canine traction more quickly than anchorage with TPA [13]. In a similar study, Heravi *et al.* divided 34 palatally IMC into two groups. In the control group, a TPA was placed, and a cantilever spring was soldered to the palatal bar. To traction 19 palatally IMC in the experimental group, 38 miniscrews were inserted for anchorage reinforcement. The cantilever spring was inserted into the slot of the miniscrews. A 50-*g* force was applied to the IMC by the cantilever spring. All IC erupted into the oral cavity, so the clinical success rate was 100%. The TADs survival rate was 94.7%. There was no statistically significant difference in the duration of the forced eruption between the two groups. Patient pain experiences were also not different. The study also concluded that disimpacting palatally IMC before aligning the teeth may reduce root resorption [17]. IMC have a higher probability of palatal impaction and cause resorption of the adjacent root as they are located mesially. Therefore, Yang *et al*. highlighted that it is important to analyze the radiographical characteristics of the impacted tooth to establish the best treatment [6].

Baruah *et al.* combined several methods to reposition the canine correctly. Initially, a mini-implant changed the canine inclination from horizontal to slightly more vertical and moved the crown tip of the canines away from the incisor roots. A vertical force vector was then applied from the hook of a modified Nance button. Finally, a cantilever spring was used to rotate counterclockwise and verticalize the canine [7]. Also in 2021, Stabryła *et al.* carried out a retrospective study to evaluate different treatment methods for IMC and impacted mandibular canines (IMandC). The most applied treatment for IMC was orthodontic traction after surgical exposure (n = 65). This method was the second most used in the lower arch and allowed traction of a third of the IMandC (n = 8). The four different methods applied in the maxillary arch are transpalatal bar (n = 47), fixed appliance (n = 14), miniscrew (n = 3) and removable appliance (n = 1). The orthodontic traction effectively treated 95% of IMC and 100% of IMandC [16]. Potrubacz *et al.* evaluated the time required to traction palatally IMC using a cantilever spring. This system applied an extrusive force of approximately 0.6 N. It was efficient, easy to construct and manipulate, offered favorable biomechanics thanks to the combination of a transpalatal bar, and was easy to activate predictably. A shorter treatment time was observed in male patients, and the authors concluded that the younger the patient, the shorter the IMC traction time. However, the position of the IC did not have a statistically significant effect on treatment time. The shortest treatment time was observed in patients aged 11 to 12 years. Of the 30 canines examined, there was only one case where the cantilever broke and two cases where the bracket failed to bond to the canine [14].

In a study performed by Pithon *et al.*, an incisor projection was performed to gain space in the arch for the IMC. The cantilever was supported on the lingual tube of the upper first molars. The treatment objectives were achieved, and the canines were perfectly repositioned [23]. In 2022, Singh *et al.* presented another series of cases using different methods for orthodontic traction. They also used a cantilever spring supported by the upper first molar. The cantilever was activated to verticalize the canine through consistent force. However, as the force was applied at a single point, an adequate torque correction was not possible. When a cantilever spring supported by the TAD was used, the TAD prevented the reactionary intrusive force and mesial inclination of the molar [18]. One year before, in 2021, Mampieri *et al.* combined aligners with elastics as aids to traction the IC. Good aesthetics can be achieved, as the absence of canines can be disguised. In treatment with aligners, the forces are released on all the upper teeth, leading only to slight intrusion. Unlike fixed braces, aligners do not have the problem of bracket detachment due to traction forces. When the canine is in a good location, in the middle of the alveolar ridge and not too deep, it can be guided using aligners and elastic traction [20].

Cruz *et al.*, as well as Singh *et al*., concluded that the use of intermaxillary elastics requires good cooperation from the patient, which contributes to treatment success. Intermaxillary elastics can also improve intercuspation [18,22]. Furthermore, Venugopal *et al.* reported a clinical case where a mini-implant was placed in the lower arch to traction the IMC. The patient was instructed to wear the elastics all day and change them every 8-12 hours. The traction force on activation was about 150 *g*. The patient reported some tongue interference and discomfort during the traction process [19]. In the initial phase of treatment, Taffarel *et al.* used a modified Haas-type palatal expander to expand the maxillary arch, increasing space to align the anterior teeth and level the IMC. After this expansion, the deciduous canine was extracted, and then a closed flap technique and bonding of an orthodontic mesh with a ligature wire was performed [24]. Moreover, Taffarel *et al.* combined several methods, such as silk thread, elastic chains, and ligature wire. When the canine clinical crown height was adequate in the arch, the final alignment was performed with “L”-shaped multi-loop arches and double helix loops. After 38 months of treatment, the IMC was correctly positioned into the occlusion line [24]. Lastly, Grenga *et al.* applied

stabilization devices (TPA/rapid palatal expander) to reduce the traction side effects and gain space for the canine's subsequent repositioning. After the closed approach with ultrasonic surgery, traction began as soon as the metal ligatures were gradually activated. The duration of the canine repositioning was 6±2 months. A closed technique with traction combined with ultrasonic surgery for disocclusion allows the IMC to be aligned without causing periodontal damage [15]. This way, it is possible to correctly traction IC using different techniques and avoid damage to adjacent teeth and periodontal tissues.

Regarding the study's limitations, among the 14 studies included, only six presented sizable samples of patients with IC. Therefore, eight relevant case reports were selected and included. Clinical trials can establish more robust scientific evidence than case reports. There may be some risk of bias in choosing several case reports for this review. However, the lack of more studies in the current literature reinforces the need to carry out more future studies on this topic, with large samples of patients. Furthermore, most article results only present whether the canine was correctly realigned in the arch without measuring orthodontic movements during traction.

Management of IC requires meticulous diagnosis and treatment planning. Despite ongoing debate over the most effective traction method, factors such as tooth position, arch space, and patient cooperation are essential in determining the ideal approach. TADs are the best anchorage option as they allow precise force control and minimize undesirable side effects on adjacent teeth. Combined with a cantilever or elastics, they usually enable effective treatment. If orthodontic traction is the chosen approach, it is necessary to have a multidisciplinary approach between various areas of dentistry.

Although aligners together with adjuvant methods show potential as an alternative to conventional methods, more studies are needed to validate their effectiveness. Ultimately, selecting the appropriate traction strategy is critical to achieving successful results in the orthodontic management of IC.

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Author Contributions

JPC designed and conceived the review, acquired, analyzed, and interpreted data, and wrote the manuscript. RA helped evaluate quality assessment and reviewed the manuscript. ASR revised the manuscript. TP conceived and designed the work, drafted and revised the manuscript. All authors read and approved the final manuscript.

Conflicts of interest

The authors declare no competing interests.

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