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Review Article

What is the impact of autotransplantation on the long-term stability and patient satisfaction of impacted canines? A Systematic Review

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ABSTRACT

Introduction: Autotransplantation is a surgical technique in which a tooth is repositioned after extraction. It is commonly used for impacted canines, which affect about 2% of the population and are more prevalent in females. These canines may remain embedded due to their late eruption. Treatment options include orthodontic appliances or autotransplantation, especially when canines are positioned too high or angled more than 45 degrees from the occlusal plane.

Aim: To review the literature regarding the effects of autotransplantation on patient satisfaction, aesthetic outcomes, and the long-term stability of autotransplantation.

Materials and Methods: This Systematic Review, registered with PROSPERO (CRD4202341), followed the PICO framework. Extensive searches were conducted in the Cochrane Library, PubMed, ScienceDirect, Scopus, VHL Regional Portal, and Web of Science, covering literature up to April 1, 2023.

Results: The review analyzed 11 studies involving the autotransplantation of 395 canine teeth, including two mandibular canines. Findings indicate higher success rates in younger patients, with a higher prevalence of transplantation in females (164) than males (105). The survival rate of transplanted canines was up to 67.9 % after 21 years, with some surviving up to 27.8 years. Success factors included young age, female gender, minimal extraoral time, proper root canal treatment, and effective post-operative care. Negative factors included ankylosis, root resorption, root fractures, infections, and periodontal issues. Complications included tooth darkening and the need for crowning. Patient satisfaction was rarely reported, with only three studies mentioning it and none addressing quality-of-life directly.

Conclusion: Canine autotransplantation is viable for selected patients when other treatments are insufficient. Despite various influencing factors, consensus guidelines for procedural decisions still need to be improved, and reports on patient satisfaction and quality-of-life impacts should be more frequent.

1. Introduction

Impacted teeth are those that remain partially or fully embedded in the bone or mucosa of the maxilla or mandible for more than two years after their normal eruption time. Canines are more frequently impacted than other teeth, with upper canines affecting approximately 2% of the population. This condition is more common in females than males at a ratio of 3:1 and affects both sides of the dental arch in 8–10 % of cases (TP 1967; Ahlberg et al. 1983). Maxillary canines, excluding wisdom teeth, have the highest risk of impaction, with an occurrence rate of 0.9% to 2.2% (Grover and Lorton 1985).

Class II malocclusions and the role of mechanoreceptors can significantly contribute to the development of canine inclusions. Class II malocclusions, where the upper teeth overlap the lower teeth excessively, can create a lack of space for canines to erupt properly. This misalignment obstructs the natural eruption path of the canines, increasing the chances of impaction (Perillo et al. 2012).

Mechanoreceptors, sensory receptors in the periodontal ligament, are crucial for sensing tooth pressure and position. If these receptors malfunction or if there is abnormal pressure due to malocclusion, the signals for proper tooth eruption may be disrupted. This disruption can lead to improper positioning and the inclusion of canines (Piancino et al.

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2017).

Treatment options for impacted canines include orthodontic disinclusion and surgical autotransplantation. Canine autotransplantation involves extracting a canine and implanting it in another location in the mouth to replace a missing tooth, while disinclusion exposes and moves the canine to its correct position, aiming to improve aesthetics and functionality with potentially shorter healing time (Cruz 2019).

Intentional replantation is a related procedure where a tooth is deliberately extracted, evaluated, treated endodontically, and replanted into its original socket (Bender and Rossman 1993). The advantage of this method is the direct inspection and repair of tooth surfaces without harming adjacent periodontal tissues. However, concerns about periodontal ligament damage, ankylosis, and external root resorption make it a last resort for many clinicians (Garcia 2013).

Tooth autotransplantation, the transfer of unerupted or erupted teeth within the same individual to extraction sites or prepared sockets (Natiella, Armitage, and Greene 1970), is a valid option for repositioning impacted canines (Grisar et al. 2019; Huth et al. 2013). It is particularly useful when the tooth is positioned too high, angled over 45 degrees relative to the occlusal plane, or unsuitable for orthodontic traction, especially when dental implants are not recommended (Grisar et al. 2021; Sinko et al. 2016; Kokai et al. 2015).

Permanent maxillary canines are crucial for occlusal stability, aesthetics, and lip support. However, no Systematic Review analyzes the aesthetic and radiographic parameters of maxillary or mandibular canines (Tsukiboshi 2002; Almpani, Papageorgiou, and Papadopoulos 2015).

This manuscript is a Systematic Review focused on the long-term stability and patient satisfaction of autotransplantation of maxillary and mandibular canines. It emphasizes aesthetic outcomes and periodontal health, addressing a significant gap in existing literature regarding long-term patient satisfaction and quality-of-life. By evaluating prospective and retrospective studies, clinical trials, and case reports, this Systematic Review aims to provide a clearer understanding of the success factors and complications associated with canine autotransplantation, offering valuable insights for clinical practice and future research (Quinzi et al. 2020; Saccomanno et al. 2021).

2. Materials and Methods

2.1. Guidelines

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed as closely as possible to ensure a comprehensive review (Page et al. 2021)(Fig. 1).

2.1.1. PICO question

This Systematic Review followed PICO guidelines to evaluate autotransplantation, focusing on patients aged 10 to 50 years with included canines, irrespective of gender or malocclusion status, and with complete or incomplete root development, who are undergoing mandibular or maxillary canine autotransplantation. The intervention of interest was autotransplantation, compared to patients without autotransplantation. The outcomes assessed included the benefits of autotransplantation, patient satisfaction, periodontal health, and the long-term stability of the results. Patients without canine inclusion or dental trauma were excluded in that Systematic Review.

2.1.2. Search strategy

The research protocol was registered with PROSPERO

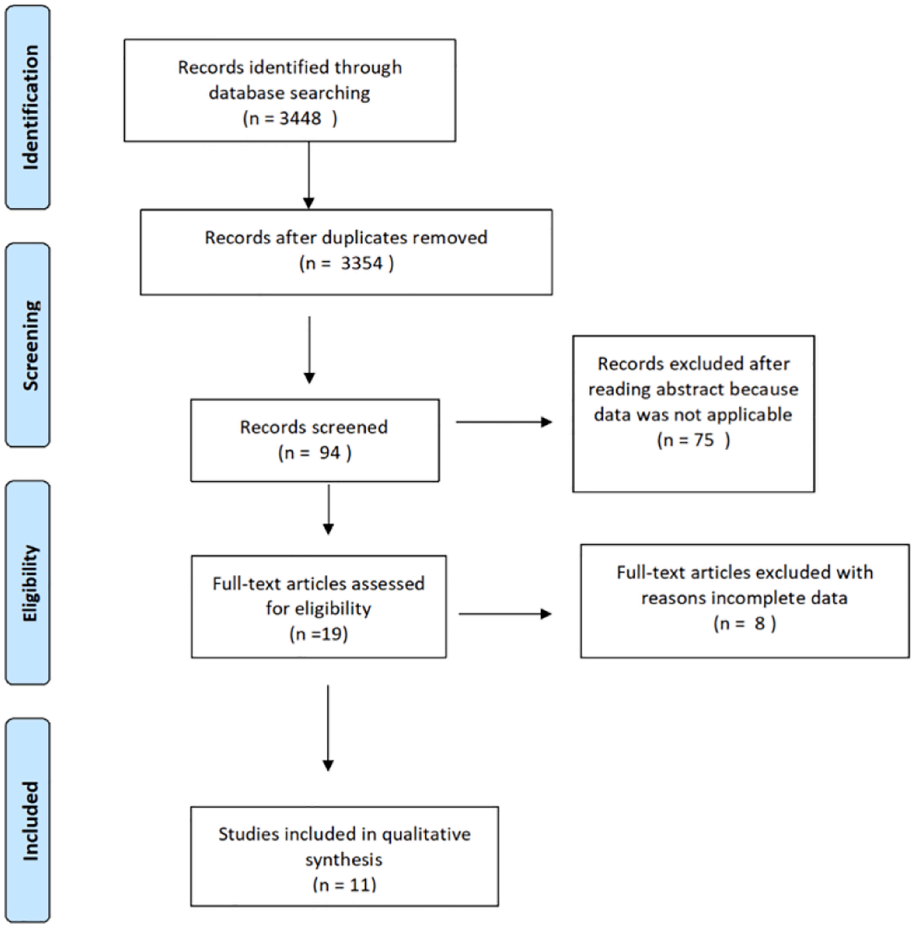


Fig. 1. Flow chart: summary of the selection process according to the PRISMA guidelines.

(CRD42023413441), the main database for Systematic Review protocols. A bibliographic review of autotransplantation was conducted, covering the period from 1991 to April 1, 2023. The databases searched included Cochrane Library, PubMed, ScienceDirect, Scopus, VHL Regional Portal, and Web of Science.

The search terms included autogenous canine autotransplantation, survival rate and periodontal parameters, impacted canines, follow-up, ectopic canines, and survival and success. Only English-language articles were considered, and references were manually selected.

2.1.3. Study selection

The selection process for this study occurred in two stages. First, studies were evaluated based on the following inclusion criteria:

A. Autotransplantation of impacted canines and their long-term stability.
B. Inclusion of prospective and retrospective studies, human clinical trials, controlled or randomized clinical trials, and case reports on maxillary or mandibular canines.
C. Only articles assessing the long-term stability of the treatment were selected.

Searches were re-checked before the final analysis (Fig. 1).

2.1.4. Data extraction and screening

In the second stage, four researchers (S.S., D.DG, E.F., C.V.) independently extracted data, with discrepancies resolved by two other authors. Data recording was done manually using Microsoft Excel.

Only studies meeting the initial inclusion criteria advanced to the second phase, applying the following exclusion criteria:

A. Studies before 1990;
B. Incomplete studies;
C. Articles lacking long-term stability data;
D. Studies focusing only on extraction therapy;
E. *In vitro* and animal research;
F. Review articles.

2.1.5. Data analysis

This Systematic Review included original studies, comparative studies, and research journal articles. Data were collected in eight key areas, as listed in Table 1, and were based on these data groups from the selected articles.

The Systematic Review considered prospective and retrospective studies evaluating transalveolar transplantation of maxillary or mandibular canines, as well as controlled or randomized clinical trials and case reports. Although we aimed to gather extensive data on periodontal issues related to autotransplanted canines, the number of relevant studies was too few for meaningful comparison. Two articles provided data on periodontal attachment, including pocket depth, periodontal space, and gingival recession (Kokai et al. 2015; Schatz and Joho 1993).

Aesthetic outcomes were evaluated using patient satisfaction, objective criteria like radiographic imaging, and the maxillary canine aesthetic index (MCAI). The starting date of the studies was not restricted. The primary focus was on aesthetic and long-term stability following transplantation, so control groups were not required. However, some studies included control groups with similar cases without autotransplantation or with disinclusion of the canines.

For studies with unclear designs, the corresponding authors were contacted for clarification. If contact could not be established and the study remained inadequately documented, it was excluded from the Systematic Review.

2.1.6. Quality assessment

Four reviewers (S.S., D.D., E.F., C.V.,) independently evaluated the risk of bias, which is summarized in Fig. 2.

2.1.7. Outcome measures

The outcome was to evaluate the benefit of autotransplantation in relation to thepatient's satisfaction and the long-term stability of the results.

2.1.8. Level of Evidence

Levels of evidence followed the Grading Recommendations of the Grade Working Group and the 11 final studies were considered suitable for level 2B.

Table 1
Summary of the 11 articles considered in the systematic review.

Author	Year	Age (Years)	Sample	Follow up (Years)	Type of study	Apex maturation	Endodontic treatment
Arikan F (Arikan, Nizam, and Sonmez 2008)	2008	25–55	30 (21F and 9 M)	5.87	Longitudinal study	Closed	Yes, performed within 1 year after the transplantation
Schatz JP(Schatz and Joho 1993)	1993	17.7	20	10.2	Clinical study	Closed	Yes, in all cases of group B
Xu L(Xu et al. 2021)	2021	45	1	7	Case report	Closed	Extraoral endodontic treatment
Grisar K (Grisar et al. 2019)	2019	20.7	71 (38F, 33 M)	21	Clinical study	Open = 25; Closed = 59	After transplantation: 13 teeth
Kim EC (Kim and Kulkarni 2020)	2020	13	1	1.5	Case report	Closed	No
Gonnissen H(Gonnissen et al. 2010)	2010	20.7	59 (25F, 34 M)	11	Clinical study	Open = 17; Closed = 38 Missing = 18	Performed in patients > 20 years (closed apex) and in all cases of pulp infection
Ozdemir et al.(Ozdemir-Ozenen et al. 2014)	2014	9	1	4	Case report	Open	Yes
Kokai S et al.(Kokai et al. 2015)	2015	29.1	89 (69F, 20 M)	5.8	Retrospective study	Closed	Two weeks after transplantation
Grisar K (Grisar et al. 2021)	2021	18	17 (10F, 7 M)	2.4	Prospective case-control study	Not specified	Performed in all transplanted canines with a closed apex
Patel S (Patel et al. 2011)	2011	21.8	49	14.5	Retrospective investigation	Closed	Not performed prior to or after implantation as part of the treatment plan
Zufía J(Zufía et al. 2020)	2020	40	1	4	Case report	Closed	Yes

F (Female); M (Male).

Fig. 2. Summary of the risk of bias for each article included in the Systematic Review.

3. Results

3.1. Assessment of risk of bias

The studies were analyzed as low, high, or unclear risk of bias, (Fig. 2). The quality of individual studies was evaluated based on the categorized ranking of the Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence.

3.1.1. Effects of interventions

The analysis of the included studies reveals a wide range of outcomes and complications associated with tooth transplantation, highlighting variability in success rates and factors influencing long-term survival. Across the studies, the age of patients ranged from 9 (Ozdemir-Ozenen et al. 2014) to 45 years (Xu et al. 2021), with both genders represented. The number of teeth transplanted varied significantly, with some studies involving as few as 1 tooth (Xu et al. 2021) and others up to 100 teeth (Kokai et al. 2015). Satisfaction with aesthetic results was generally high, although specific measures of satisfaction were not always detailed. Follow-up periods ranged from 1.5 (Kim and Kulkarni 2020) to 26.6 years (Patel et al. 2011), providing a broad spectrum of long-term data.

Common complications included root resorption, both external and inflammatory, ankylosis, pulp necrosis, and periodontal issues. For example, Schatz et al. (Schatz and Joho 1993) reported varying degrees of pulp obliteration and root resorption, while Gonnissen et al. (Gonnissen et al. 2010) noted a 38.2 % incidence of root resorption. Grisar et al. (Grisar et al. 2019) identified extensive complications such as tooth ankylosis and gum recession, while Patel et al. (Patel et al. 2011) observed significant instances of internal and external root resorption and periodontal problems.

Survival rates of transplanted teeth varied across studies. High survival rates were noted by Arikan et al. (Arikan, Nizam, and Sonmez 2008) at 93.5 %, Xu et al. (Xu et al. 2021) and Kim et al. (Kim and Kulkarni 2020) both at 100 %, and Zufía et al. (Zufía et al. 2020) also at 100 %. Conversely, lower survival rates were reported by Gonnissen et al. (Gonnissen et al. 2010) at 57.5 % and Patel et al. (Patel et al. 2011) at 38 %, indicating significant variability. (Fig. 3A).

Teeth survival rates are generally high (close to 100 %) for shorter follow-up periods (around 0–5 years). However, as the follow-up period increases, there is a noticeable decrease in the survival rate, with significant variability for periods between 5 to 25 years. Some studies show very low survival rates even at shorter follow-up periods. (Fig. 3B).

Most studies report high satisfaction rates around 4 (on a scale from 0 to 4). However, there is a downward trend in satisfaction over longer follow-up periods, as indicated by the red dashed trend line. Despite this trend, most data points still indicate relatively high satisfaction rates. Overall, the survival rate tends to decrease with longer follow-up periods, while satisfaction rates, though slightly declining, remain relatively high. (Fig. 3C).

Orthodontic treatments were often employed either before or after transplantation to aid in tooth stabilization and alignment. The use of splints, ranging from flexible to limited splints with composite and wire, was common in postoperative care, contributing to the stabilization of transplanted teeth.

While tooth transplantation shows promise with relatively high satisfaction and survival rates in many cases, the success is tempered by the potential for significant complications. The variability in outcomes underscores the importance of careful patient selection, meticulous surgical technique, and rigorous follow-up to manage and mitigate these risks (Table 2).

3.1.2. The impact of patient age on the success rate of tooth autotransplantation

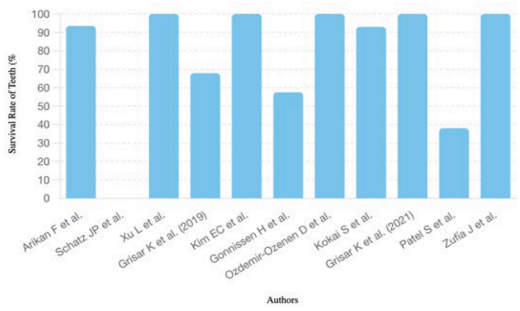
The success rate of autotransplantation of teeth is significantly influenced by the patient's age at the time of the procedure. Studies have shown that younger patients, particularly those under 40, experience success rates exceeding 90 % (Tsukiboshi and Andreasen 2001). This is corroborated by the studies included in this Systematic Review (Fig. 3A). The negative correlation between age and success rate suggests that younger patients have better healing capacities, contributing to higher success rates (Gonnissen et al. 2010; Grisar et al. 2019). Older age at the time of transplantation could reduce success rates, especially if the procedure is done after the ideal developmental stage of the tooth(Grisar et al. 2021). While some studies, like Kokai's, argue that age is not a significant factor (Kokai et al. 2015), viable periodontal ligament cells and the developmental stage of the transplanted tooth are crucial for success (Kristerson 1985; Kallu et al. 2005).

However, the survival rate of teeth remains relatively high across different ages, with most data points clustered around 100 %. However, there are some variations, particularly among patients aged 20 years, where the survival rate shows significant variability. Overall, the survival rate appears to be less influenced by age. (Fig. 4A). Younger patients tend to have longer follow-up periods, while older patients have shorter follow-up periods. This could suggest that younger patients are monitored over a more extended period. (Fig. 4B).

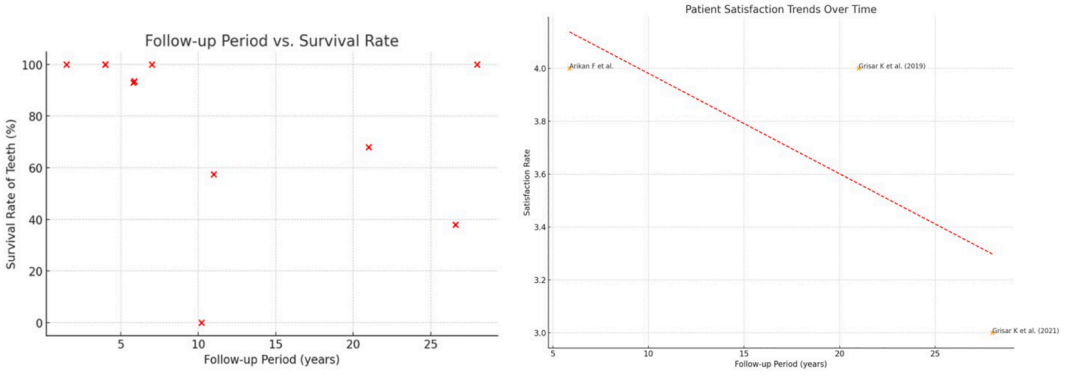
4. Discussion

For impacted canines, particularly maxillary ones, early interceptive surgical therapy is the gold standard, providing the best long-term outcomes through surgical exposure and orthodontic traction (Quinzi et al. 2019). Treatment plans should consider the position of the impacted canine and the patient's age, as palatally positioned canines have a worse prognosis than labially positioned ones (Chapokas, Almas, and Schincaglia 2012; Sajnani and King 2012). In adults and similar conditions, the success rate of orthodontic traction is lower than that of autotransplantation, with the prognosis worsening with age (Quinzi et al. 2020).

Recovering canines solely through disinclusion is difficult due to



(A)



(B) (C)

Fig. 3. (A) The survival rate of autotransplanted teeth analyzed in the included studies; (B) The relationship between the follow-up period and the survival rate of teeth. (C) Patient satisfaction trends over time.

poor prognosis, making autotransplantation a more viable option (Tsukiboshi 2002; Almpani, Papageorgiou, and Papadopoulos 2015). This procedure involves moving a tooth within the same patient, ideally without endodontic treatment. However, in this Systematic Review, most transplanted teeth, especially in older patients, required devitalization before or after surgery to prevent pulp necrosis, control resorption, and avoid discoloration (Patel et al. 2011). Nearly half of the surviving teeth exhibited discoloration and some required crowns.

Autotransplantation success relies on the surgeon's technique, minimal extraoral handling time, preserving vital ligament cells, proper splinting, effective endodontic treatment, and good oral hygiene (Tsukiboshi 2002; Patel et al. 2011; Ozdemir-Ozenen et al. 2014). Failures can arise from ankylosis, inflammatory resorption, or marginal periodontitis, making this procedure suitable for specific cases where other treatments are inadequate.

Radiographic analysis often fails to detect ankylosis, which becomes evident after attempting dis-inclusion. Root and coronal fractures during surgery are potential risks when removing ankylosed canines (Arikan, Nizam, and Sonmez 2008; Kokai et al. 2015).

The review's limitations include a small, heterogeneous sample size and varying follow-up periods, with some cases extending to 27.8 years post-surgery (Patel et al. 2011). Inconsistent protocols and periodontal reports further limit the findings. Children's transplanted teeth generally have better outcomes than those in adults, a discrepancy not fully understood (Gonnissen et al. 2010; Al-Zoubi et al. 2017; Xu et al. 2021).

Given the importance of canines for occlusion and aesthetics, patient satisfaction is crucial yet underreported, with only 3 of 11 articles addressing it (Grisar et al. 2019; 2021; Schatz and Joho 1993). Future studies should focus on long-term patient satisfaction and early risk assessment for canine impaction. Early orthodontic interventions to prevent canine impaction are essential (Grippaudo et al. 2020; Gelb et al. 2021).

Tooth inclusion, especially of canines, can significantly increase the risk of malocclusion, impacting the quality-of-life in orthodontic patients (Grippaudo et al. 2020). Malocclusion can cause issues like difficulty chewing, speech problems, and poor oral hygiene leading to periodontal disease and cavities(Chiba et al. 2022). Early management of tooth inclusion through orthodontic or surgical interventions can prevent these problems (Gelb et al. 2021). Effective orthodontic treatment can enhance oral function, improve facial aesthetics, and boost patient confidence. This, in turn, enhances the quality-of-life by reducing discomfort, improving dental efficiency, and promoting overall oral health. Therefore, early preventive orthodontic strategies are essential for achieving better long-term outcomes and patient satisfaction (Chiba et al. 2022). Additionally, dental control and monitoring can be effectively managed with teledentistry, providing convenient and accessible care (Valeri et al. 2023).

5. Conclusion

Canine autotransplantation has shown promising results. The procedure's success is highly dependent on various factors, including the tooth's position, timely endodontic treatment, and effective management of periodontal conditions. The combination of a refined surgical technique, patient-specific considerations, and meticulous postoperative care plays a critical role in the overall success of the procedure. The survival rate appears to be less influenced by age.

Although transplanted canines can survive for extended periods, with some cases showing survival of up to 27.8 years, the survival rate tends to decrease over time. This underscores the importance of long-term follow-up to monitor and maintain the health of the transplanted teeth. Additionally, supplementary orthodontic treatments are often required to stabilize the occlusion and the transplanted teeth. These treatments vary from case to case, necessitating a tailored approach to each patient's needs.

One notable gap in the current research is the need for

Table 2
Summary of factors involved in success or failure of canine autotransplantation.

Authors	Therapy	Age (Years)	Gender	# of teeth at T0	Rate of satisfaction	Follow-up	Reasons for unsuccessful results	Results	Orthodontic treatment during or after AT	Survival rate of teeth
Arikan F et al. (Arikan, Nizam, and Sonmez 2008)	A*	34.32	21F, 9 M	32C*	Subjects were happy with the esthetic results.	5.87 years	Damaged crowns during surgical removal, root resorption, tooth extraction (year 4)	Root resorption in two teeth	Limited splinter with composite and wire for 4 weeks	93.5 %
Schatz JP et al. (Schatz and Joho 1993)	A*	17.7 (group A: 13–20 years; 32.1 (group B: 20–48 years)	/	20 (17 MC* & 1 MdC*)	/	10.2 years	Pulp necrosis, inflammatory root resorption, bone and tooth resorption	– Group A (n = 10): – Pulp obliteration: – Partial: 60 % – Total: 20 % – Replacement root resorption: 0 % – Inflammatory root resorption: 10 % – Pulp necrosis: 10 % – Group B (n = 10): – Pulp obliteration: – Partial: 0 % – Total: 0 % – Replacement root resorption: 20 % – Inflammatory root resorption: 0 % – Pulp necrosis: 0 %	Limited splinter or full ortho treatment	/
Xu L et al.(Xu et al. 2021)	A*	45	1 M	1C*	/	7-years	/	No inflammation or root resorption	Flexible splint for 30 days	100 %
Grisar K et al.(Grisar et al. 2019)	A*	20.7	38F, 33 M	84C*	High long-term patient satisfaction.	21 years	Tooth ankylosis, extensive gum recession, tooth resorption, apical infection, damage to the periodontal ligament	– Total number of canines examined: 27 – Periotest values: – Negative: 17 teeth – Higher than normal: 2 teeth – Normal: 8 teeth – Tooth mobility: – Grade 2 mobility: 2 transplanted teeth – No altered mobility in contralateral canines – Endodontic values: – Examined for vitality: 14 teeth – Positive cold test: 5 teeth – Mean PDL: 3.0 (SD 1.5) – Bleeding on probing: 7 teeth – Suspected ankylosis: 6 teeth – Discoloration: – Major: 4 teeth – Minor: 5 teeth – Normal: All other transplanted teeth – MCAI: – Excellent: 16 teeth – Good: 9 teeth – Acceptable: 1 tooth – Poor: 1 tooth – Gum recession: 2 teeth – Buccolingual inclination deviation 6 teeth – AMCRI: – Excellent: 12 teeth – Good: 3 teeth – Acceptable: 7 teeth	Yes	67.9 %,

(continued on next page)

Table 2 (*continued*)

Authors	Therapy	Age (Years)	Gender	# of teeth at T0	Rate of satisfaction	Follow-up	Reasons for unsuccessful results	Results	Orthodontic treatment during or after AT	Survival rate of teeth
								– Poor: 4 teeth – External root resorption: 9 teeth – Apical infection: 3 teeth – Ankylosis: 4 teeth – Apical pathology: 3 teeth		
Kim EC et al. (Kim and Kulkarni 2020)	A*	13	1 F	2C*	/	1.5 years	/	– Clinical condition: Asymptomatic – Thermal response: Normal – Radiographic findings: Normal – Mobility: Normal – PDL: < 1.5 mm –Periapical Radiograph: Normal	Yes postoperative	100 %
Gonnissen H et al.(Gonnissen et al. 2010)	A*	20.7	25F, 34 M	73C*	/	11 years	Progressive root resorption, pathological pockets, bone loss, apical inflammation	– Negative Periotest values (lost mobility): 35 teeth (63.6 %) – Higher than normal Periotest values (clinically mobile): 2 teeth (3.6 %) – Normal Periotest values: 18 teeth (32.7 %) – Tooth vitality (excluded 33 teeth with endodontic treatment): – Positive cold test: 1 tooth (3.0 %) – Positive electric pulp test: 4 teeth (12.1 %) – PDL: – Unacceptable (>3 mm): 11 teeth (20.0 %) – Acceptable (≤3 mm): Remaining teeth – Moderate inflammation (gingiva bled while probing): 13 teeth (23.6 %) – Root resorption: 21 teeth (38.2 %) – No resorption: 34 teeth (61.8 %) – External root resorption: 19 teeth (90.5 % of resorptive teeth) – Internal root resorption: 2 teeth (9.5 % of resorptive teeth) – Pulp chamber: – No significant changes: 14 teeth (25.4 %) – Reduction in size or complete obliteration: Remaining teeth (excluding endodontically treated teeth) – Lamina dura: – Intact: 29 teeth (52.7 %) – Not detectable: 15	Yes	57.5 %

(*continued on next page*)

Table 2 (*continued*)

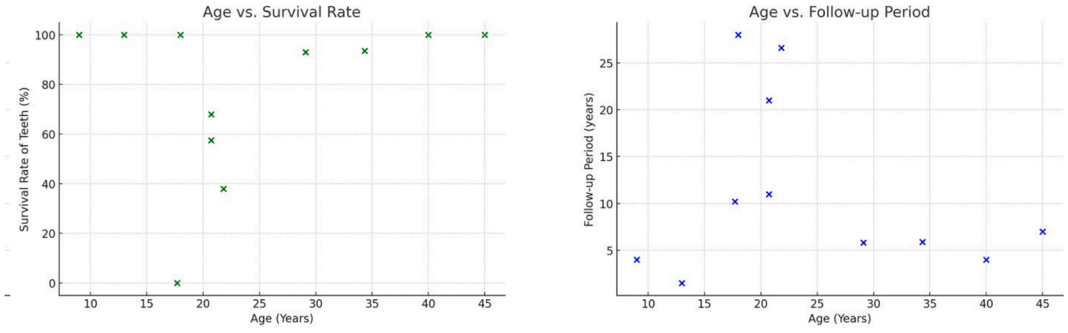
Authors	Therapy	Age (Years)	Gender	# of teeth at T0	Rate of satisfaction	Follow-up	Reasons for unsuccessful results	Results	Orthodontic treatment during or after AT	Survival rate of teeth
								teeth (27.3 %) – Missing part of the lamina dura: 11 teeth (20.0 %) – Extensive alveolar bone loss: 6 teeth (10.9 %) – Apical inflammation: 3 teeth (5.4 %)		
Ozdemir-Ozenen D et al.(Ozdemir-Ozenen et al. 2014)	A*	9	1 M	1 MdC*	/	4 years	/	– External inflammatory root resorption treated with conventional apexification – Complete healing observed both clinically and radiographically.	Yes for 2 weeks	100 %
Kokai S et al. (Kokai et al. 2015)	A*	29.1	89 (69F, 20 M)	100C*	/	5.8 years	Ankylosis, tooth resorption, root fracture, attachment loss, periodical lesions, periodontal pockets	Slightly higher success rate in males (72.8 %) compared to females (70.5 %). Common complications among surviving teeth included ankylosis and root resorption. A small percentage of teeth fell out, due to ankylosis, root resorption or root fracture, and attachment loss.	Yes, before and after	93 %
Grisar K et al.(Grisar et al. 2021)	A*	18	10F; 7 M	17C*	Clinically satisfactory outcomes in 1–3 years of follow-up.	28 months (range, 12–40 months).	Inflammatory tooth resorption, ankylosis, extra- oral time during transplantation	2 weeks: – Oral hygiene: – Good: 15 – Average: 2 – Poor: 0 – Palpation: – Not painful: 16 – Painful: 1 – Colour: – Intact: 14 – Damaged: 3 – Gingival inflammation (Loë Index): – Normal: 13 – Pathological pockets (≥3 mm): 0 – Mobility: – Peri-apical radiolucency: 0 1 week: – Oral hygiene: – Good: 12 – Average: 5 – Poor: 0 – Palpation: – Not painful: 15 – Painful: 2 6 weeks: – Oral hygiene: – Good: 14 – Average: 1 – Poor: 0 – Palpation: – Not painful: 17 – Painful: 0 – Inflammatory root resorption: – Yes: 2	Yes postoperative	100 %

(*continued on next page*)

Table 2 (*continued*)

Authors	Therapy	Age (Years)	Gender	# of teeth at T0	Rate of satisfaction	Follow-up	Reasons for unsuccessful results	Results	Orthodontic treatment during or after AT	Survival rate of teeth
								– No: 15 – PDL – No: 15 – Yes: 13		
Patel S et al. (Patel et al. 2011)	A*	21.8	/	63C*	/	Over 26.6 years	Darkened color (replaced with a crown), need for root canal procedure, internal root resorption, inflammatory tooth resorption, periodontal problems	– PDL: 2.24 mm – 81 % exhibited bleeding on probing –Vitality Testing: 54 % negative response to ethyl chloride; 6 % tender to percussion –Gingival Recession: 83 % 3—–5 mm – Tooth Mobility: Normal – Tooth Color: 63 % normal; 19 % darker; 18 % color changes – Internal Root Resorption: 9 % exhibited signs; 2 had been root treated – External Inflammatory Root Resorption: 21 % showed signs; 2 were root treated – Endodontic Treatment: 65 % had undergone root treatment and were still in situ – Bone Loss: 94 % presented with less than one-third of root length bone loss; remaining 6 % showed more than half, indicating replacement resorption.	Splint for 2 weeks	38 %
Zufía J et al. (Zufía et al. 2020)	A*	40	1 F	2C*	/	4-year	/	Root Resorption: None Ankylosis: None Inflammation: None Bleeding: None	Yes, before and after	100 %

A*: Autotrasplantation; C: Canine; M: Maxillary; Md: Mandibular; /: Not specified; MCAI: Maxillary Canine Aesthetic Index; AMCRI: Autotransplanted Maxillary Canine Radiographical Index; PDL: periodontal ligament.



(A) **(B)**

Fig. 4. (A) The relationship between patient's age and the survival rate of teeth; (B) The relationship between the age of the participants and the follow-up period in years.

comprehensive data on patient satisfaction, with only 3 out of 11 studies addressing this aspect. This indicates a significant area for future research, as patient satisfaction is a crucial metric for evaluating the overall success of medical procedures. Standardizing treatment protocols and incorporating patient satisfaction metrics in future studies could enhance the outcomes of canine autotransplantation.

In conclusion, canine autotransplantation can be a successful and long-lasting solution, mainly when performed early and with individualized treatment plans. Future research should standardize protocols and emphasise patient satisfaction to improve the overall effectiveness and acceptance of this procedure.

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7. Institutional Review Board Statement

Not applicable.

8. Informed Consent Statement

Not applicable.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sdentj.2024.08.006.

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