

Autotransplantation of teeth: an evidence-based approach

K. Martin,^{*1} S. Nathwani² and R. Bunyan³

Key points

Presents an overview of autotransplantation as a surgical technique for replacing missing teeth.

Reviews the current evidence on autotransplantation.

Highlights the difficulties in replacing missing teeth in the paediatric patient.

Outlines an evidence-based approach for treating patients undergoing autotransplantation.

Background Dental autotransplantation involves the extraction of a tooth from one site, to be implanted into another, within the same patient's oral cavity. Although today the dental implant is the preferred choice of treatment, this is not always appropriate in the paediatric patient. **Aim** The aim of this review is to identify the principles of autotransplantation using an evidence-based approach. **Methods** A literature review was conducted in June 2017 of free text and MESH searches (keywords 'transplantation of tooth', 'autotransplantation') in the Cochrane Library; PubMed, trial registers, professional bodies for guidelines and OpenGrey were also searched. Inclusion and exclusion criteria were applied to identify literature outlining the orthodontic and surgical principles for autotransplantation. **Results** One hundred and sixty-one articles were identified in the initial literature search. Only 45 studies were relevant to autotransplantation of teeth. A further 41 studies were excluded due to a high risk of heterogeneity, bias and weak methodological quality. Four systematic reviews were identified for critical appraisal. All studies identified a success and survival rate of >81%. **Conclusion** Despite the success and survival rate of autotransplanted teeth being seemingly high, results must be interpreted with a degree of caution due to the lack of Level 1 evidence, with no specific evidence-based guidelines for assessment and management of patients undergoing autotransplantation. Further randomised controlled trials evaluating both the success and prognostic factors for autotransplantation of teeth are required.

Introduction

Autotransplantation (or transalveolar transplantation) is an effective yet under-used technique involving the surgical transplantation of a tooth from one site in the mouth to another in the same individual.¹ This treatment has both functional and aesthetic advantages and should be considered alongside other surgical and restorative options, including orthodontic treatment, fixed and removable

prostheses, and osseointegrated implants. It is particularly applicable to the paediatric patient and developing dentition, where other surgical options may be inappropriate (see Fig. 1).

Allotransplantation of teeth first became popular in the eighteenth century but unsurprisingly the long-term survival rates were poor given the lack of histo-compatibility and it is thought to have been a route for the transmission of syphilis (see Fig. 2).^{2,3} However, clinicians made key discoveries by identifying the use of immature teeth with an open apex and immediate replacement of the extracted tooth to maintain the vitality of both the pulp and periodontal ligament.⁴

Autogenous transplantation of teeth was first reported in the 1950s where third molars were autotransplanted into a first molar position.² Initial results demonstrated only a 50% success rate thought to be related to traumatic extraction and subsequent damage to the periodontal

ligament and cementum.² The first case series published by Slagsvold and Bjercke in 1974 described 34 cases of transplanting premolars to the anterior maxilla with 100% surgical survival rate.⁵ This provided a platform for the publication of other case series and studies with varying surgical success rates from 79% to 100%.⁴

There are several clinical indications for the autotransplantation of teeth (see Table 1). It can be performed at an early age in a growing patient given that further formation of a functional periodontal ligament can aid with the continued eruption of the tooth, preservation of the volume of alveolar bone and arch form, as well as maintenance of proprioception to aid masticatory function.⁶ As with any surgery, there are complications that can arise including pulpal necrosis, inflammatory and replacement resorption, poor periodontal healing and ankyloses.⁶ The ideal properties for donor teeth and recipient sites are outlined in Table 2.

¹DCT in Oral and Maxillofacial Surgery, ²Specialist in Oral Surgery, ³Consultant in Oral Surgery, Department of Oral and Maxillofacial Surgery, Luton and Dunstable University Hospital, Lewsey Road, Luton, LU4 0DZ

*Correspondence to: Katy Martin
Email: Katy.Martin3@nhs.net

Refereed Paper.

Accepted 19 December 2017

Published online 1 June 2018

DOI: 10.1038/sj.bdj.2018.432

Systematic reviews comparing the success rates of autotransplantation with other restorative options to replace missing teeth

are favourable; single tooth osseointegrated implants have a success rate of 95%, fixed bridges 89% and resin bonded bridge 86%.⁴

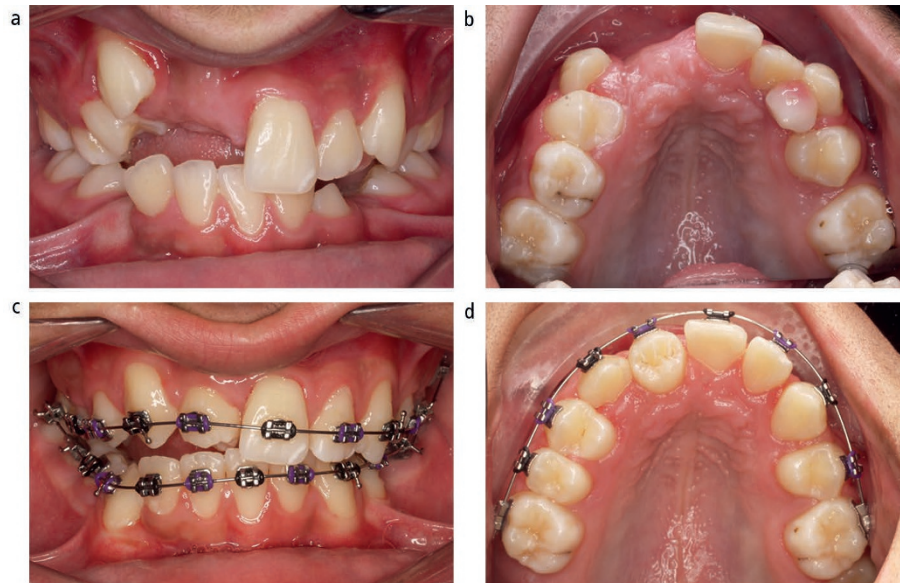


Fig. 1 a & b) Paediatric patient with traumatic loss of upper right central and lateral incisor in bicycle accident. **c & d)** Autotransplant of lower right first premolar into position of upper right central incisor

Method

A literature review was conducted in June 2017 of free-text and MESH searches with the keywords: ‘tooth’, ‘autotransplantation’ and ‘autogenous transplantation’, in the Cochrane Library, PubMed and CINAHL. Trial registers, professional bodies for guidelines and OpenGrey for unpublished literature were also searched. Singular and plural forms of words, synonyms, acronyms, different spellings, truncation, and lay and medical terminology were all used in the PICO analysis. Boolean operators ‘OR’, ‘AND’ and ‘NOT’ were all applied. Studies were selected for appraisal after limits applied (adult, human and English only studies and inclusion/exclusion criteria imposed). There were no restrictions applied to the time period.

Results

One hundred and sixty-one articles were identified in the initial literature search. Only 45 studies (retrospective descriptive studies, case reports and technical notes) were relevant to autotransplantation of teeth. There was a high risk of heterogeneity, bias and overall weak methodological quality and thus 41 studies were excluded from this review. Four systematic reviews were identified for critical appraisal using the CASP tool (see Table 3).

The evidence in this area of surgery is scarce, with no randomised controlled trials reported in the literature.

A systematic review by Atala-Acevedo *et al.* evaluated 21 studies over a 25-year period.⁷ They report limited numbers of controlled methodical studies investigating prognostic factors of autotransplanted teeth and concluded that there were no established standardised criteria to determine the success of treatment based on clinical, aesthetic and patient satisfaction parameters. The success rate described in this study was 89%, with a survival rate of 98%, with premolars reported to have a lower failure risk than molars (OR 0.46; 95% CI, 0.25–0.84).⁷ The mean follow-up time following autotransplantation was 6 years and 3 months.⁷ However, the results should be interpreted cautiously as there is a high risk of bias within the studies.

A meta-analysis by Almpani *et al.* reported the stage of root development of the donor tooth to be the most important prognostic factor in the success of autotransplantation.¹ Teeth with open apices have 70% less risk of post-autotransplantation extraction (RR = 0.3,



Fig. 2 Transplanting of Teeth by Thomas Rowlandson, hand coloured engraving, 1787 (published courtesy of The Hunterian Museum at the Royal College of Surgeons)

Table 1 Indications and contraindications of autotransplantation ^{1,4}	
Indications	Contraindications
Movement of impacted or severely ectopic teeth	Deciduous dentition
Management of congenitally absent teeth	Non-compliant patient
Premature loss of permanent dentition (caries, trauma, iatrogenic damage, developmental abnormalities)	Restored donor tooth
Growing patient	Transplantation into infected site
Correcting discrepancies between arches	

Table 2 Ideal properties of donor tooth and recipient site for autotransplantation^{1,2,6-8}

	Clinical examination	Radiographic examination
Donor tooth	Healthy virgin tooth A non-functioning position in the occlusion A tooth previously planned for an orthodontic extraction Appropriate crown width for aesthetics and function Extracted with an atraumatic technique Single > Multiple rooted teeth No increased pocket probing depths Patient age <40 years old	Open apex Root length between one-half to two-thirds completed root development Use to construct surgical template (if appropriate)
Recipient site	Free of chronic inflammation Free of acute infection Sufficient mesio-distal width Adequate bone levels Healthy attached gingivae No functional or non-functional occlusal interferences	Assessed in three dimensions (if appropriate) Proximity to adjacent structures - no involvement with maxillary sinus, mandibular canal Good adaptation to donor tooth

Table 3 Manual selection of articles suitable for critical appraisal using CASP tools

Total number of articles	161		
Relevance to autotransplantation	45 (retrospective descriptive studies, case reports and technical notes)		
Following exclusion due to weak methodology/bias	4 (systematic reviews)	➔	critical appraisal with CASP

Note: All duplicate articles were excluded.

95% CI, 0.2–0.6)¹ with the overall need for extraction of an autotransplanted tooth reported at less than 10%. The meta-analysis is formed of largely retrospective studies, and the need for prospective, controlled double-blinded studies is indicated, particularly with considerable variation in patient follow up noted.¹

Chung *et al.* report the most predictable results are for teeth transplanted when root development is between one half to two thirds completed.⁶ This study assessed outcomes of autotransplanted teeth with complete root formation and closed apical foramen, with at least a 1-year follow-up period. The estimated 1-year and 5-year survival rates were quoted at 98% and 90.5% respectively, with the estimated failure rate of autotransplanted teeth recorded at 2.0%.⁶

The autotransplantation of posterior teeth, absence of systemic antibiotics, and suture splinting method (including splinting time for less than 14 days) were influencing factors that increased failure rate.⁶ The design of this systematic review was based largely upon observational studies, which directly causes moderate study heterogeneity ($I^2 = 72\%$) and publication bias of this review.

The final study by Machado *et al.*⁸ reported a success rate of 81% using largely retrospective studies with a minimum 6-year follow up. They identify a positive response to vitality testing at 2–4 months following autotransplantation demonstrating revascularisation, particularly in transplanted teeth with an immature root apex.⁸ Both ankylosis and root resorption were reported in only 4% of cases, and influenced the prognosis of the autotransplanted tooth.⁸

Parameters for success

The parameters for determining success of autotransplantation are not clearly outlined within the articles appraised. However, it is possible to extrapolate criterion for success from other restorative and surgical treatment options to identify important factors in determining a successful autotransplantation.

Papaspyridakos *et al.* identify the most common parameters for assessing the success of implant placement to be implant level, peri-implant soft tissue, the patient's subjective evaluation and the final prosthesis.⁹ The European Society for Endodontology establish that an endodontically treated tooth requires further treatment if there are signs and symptoms of infection, signs of continuing root resorption, a periapical lesion that has failed to change in size, or evidence of a new radiographically visible lesion following treatment.¹⁰

Extrapolation of success parameters that could be applied to the success of autotransplantation include:

- Donor tooth function within the arch
- Recipient site soft tissue
- Patient's subjective evaluation of success, in terms of function and aesthetics
- Absence of infection
- Absence of root resorption
- No increase in size or new radiographically visible lesion following endodontic treatment.

Discussion

Despite the limited evidence, lack of robust clinical data and inconsistencies in the results of the studies considered, the literature review has identified that the overall surgical success and survival rates of autotransplanted teeth are high. Interestingly the non-surgical parameters for success, including patient satisfaction and aesthetic results, are not readily discussed.

All studies critically appraised in this review conclude the following:

- Autotransplantation of teeth has a success rate of >81%. Survival rate varies between studies, with five-year survival rates reported as high as 80.5%
- Autotransplantation of teeth with an immature open root apex is more favourable than those with a closed root apex (although some studies also show some success with autotransplanted teeth with closed apices¹)

- Complications that can arise include ankylosis and root resorption, although the reported rates are as low as 4%
- There is a need for randomised controlled trials evaluating autotransplantation as a surgical technique to expand the currently limited high quality evidence in this area of surgery
- Surgical technique is an important prognostic factor, but there is a lack of available data to analyse this further.

Larger and better designed studies are needed, with current studies flawed for the following reasons:

- Small populations studied
- Inconsistent surgical technique and surgeon
- Inconsistencies in the literature regarding follow up, timings of autotransplantation and need for endodontic treatment
- High risk of bias and selective heterogeneity within studies
- Statistical analysis
- Lack of consideration of patient factors for success
- Differences in definition of success and failure
- Direct comparisons with other conventional treatments.

Recommendations for practice

The following recommendations have been extrapolated from the articles appraised in the literature review:

- Tooth autotransplantation should be considered as a treatment option for replacing missing or ectopic teeth in the paediatric patient
- A comprehensive consent process is essential given the lengthy nature of treatment (surgical and orthodontic)
- A multidisciplinary treatment plan with an experienced orthodontist is essential to maximise the success, survival and

incorporation of an autotransplanted tooth in a functional and aesthetic occlusion (as well as to consider alternate treatments if in the patient's best interest)

- There is no optimal age reported for carrying out autotransplantation, although most treatment appears to be completed in early adolescence
- Two dimensional imaging is usually sufficient for radiographic planning of autotransplantation. Three dimensional imaging can be a useful adjunct to construct a surgical template of the donor tooth to contour the recipient surgical site
- Single rooted teeth (anterior and premolar teeth) have a higher success and survival rate than multi-rooted teeth
- Autotransplanted teeth with an open immature apex have a higher rate of success and survival than those with closed apices
- Atraumatic extraction of autotransplanted tooth is an important prognostic factor
- Sufficient three-dimensional augmentation of alveolar bone at the donor site aids surgery and improves success rates
- Donor and recipient sites should be free of inflammation and infection
- Timing of endodontic treatment is debated in the literature and dependent upon the stage of root development at the time of autotransplantation
- There is no statistically significant surgical method shown to increase the success and survival rates of autotransplanted teeth
- There is no statistically significant evidence for the use of prophylactic antibiotic cover following autotransplantation
- The literature suggests that splinting teeth post-operatively may help reduce instability and decelerate the rate of destruction of the periodontal ligament, but there is limited evidence to support type of splinting material and duration for transplanted teeth

- Clinical and radiographic follow up is essential to determine the apical status of the autotransplanted tooth
- A standardised surgical and follow up protocol, with specific success criterion is necessary to develop the evidence database for autotransplantation.

Conclusion

Autotransplantation is a long established surgical technique which has both a high success and survival rate, but further controlled methodical studies and research are required in this area.

Acknowledgements

The authors would like to acknowledge the Library at Luton and Dunstable University Hospital for their assistance, and Mr Ali Sattarzadeh for clinical photographs.

1. Almpani K, Papageorgiou S, Papadopoulos M. Autotransplantation of teeth in humans: a systematic review and meta-analysis. *Clin Oral Investig* 2015; **19**: 1157–1179.
2. Amos M, Day P, Littlewood S. Autotransplantation of teeth: an overview. *Dent Update* 2009; **36**: 102–113.
3. Rowlandson T. *Transplanting of Teeth*. Hand coloured engraving, 1787. RCSSC/P 3158.
4. Cross D, El-Angbawi A, McLaughlin P *et al*. Developments in autotransplantation of teeth. *Surgeon* 2013; **11**: 49–55.
5. Slagsvold O, Bjercke B. Autotransplantation of premolars with partially formed roots. A radiographic study of root growth. *Am J Orthod* 1974; **66**: 366–366.
6. Chung WC, Tu YK, Lin YH, Lu HK. Outcomes of autotransplanted teeth with complete root formation: a systematic review and meta-analysis. *J Clin Periodontol* 2014; **41**: 412–413.
7. Atala-Acevedo C, Abarca J, Martínez-Zapata M J, Díaz J, Olate S, Zaror C. Success rate of autotransplantation of teeth with an open apex: systematic review and meta-analysis. *J Oral Maxillofac Surg* 2017; **75**: 35–50.
8. Machado L, do Nascimento R, Ferreira D, Mattos C, Vilella O. Long term prognosis of tooth autotransplantation: a systematic review and meta-analysis. *Int J Oral Maxillofac Surg* 2016; **45**: 610–617.
9. Paspaspyridakos P, Chen C J, Singh M, Weber H P, Gallucci G O. Success criteria in implant dentistry: a systematic review. *J Dent Res* 2012; **91**: 242–248. DOI: 10.1177/0022034511431252.
10. European Society of Endodontology. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. *Int Endod J* 2006; **39**: 921–930..