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Splinting duration and periodontal outcomes for replanted avulsed teeth: a systematic review

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Abstract – Clinical guidelines are now available for the management of avulsed teeth. The principles of evidence-based dentistry can be used to assess whether these guidelines are based on currently-available evidence. A qualitative systematic review was conducted of relevant clinical literature to examine the evidence on splinting duration and periodontal healing outcomes. The review was constrained markedly by small sample sizes, retrospective nature of clinical audits, dissimilarities of selected studies in their design, methodology and observation periods, and lack of uniformity in terminology for outcomes. A total of 138 replanted avulsed permanent teeth pooled from four papers each reporting both short-term splinting (14 days or less) and long-term splinting (over 14 days) in accord with current clinical guidelines, were studied. The evidence for an association between short-term splinting and an increased likelihood of functional periodontal healing, acceptable healing, or decreased development of replacement resorption, appears inconclusive. The study found no evidence to contraindicate the current guidelines and suggests that the likelihood of successful periodontal healing after replantation is unaffected by splinting duration. Pending future research to the contrary, it is recommended that dentists continue to use the currently-recommended splinting periods when replanting avulsed permanent teeth.

Tooth avulsion is defined as complete displacement (exarticulation) of a tooth from its socket (1), severing the pulpal blood supply and exposing the cells of the periodontal ligament to the external environment (2). If the tooth is replanted promptly with a vital periodontal ligament, functional periodontal healing can occur (3–9). The extra-oral period significantly affects the outcome, influencing periodontal ligament vitality (10). As replanted permanent incisors are likely to be lost, even up to 20 years later (11), clinical management must optimize the long-term prognosis. Rarely encountering avulsed permanent teeth, dentists may feel inadequate in their management, including splinting and diagnosing later complications (12–16). Clinical guidelines are therefore valuable in assisting clinicians to deliver efficiently the best care possible (17). Current management aims to prevent or minimize inflammation from attachment damage and pulpal infection and promote periodontal healing (18).

Splinting stabilizes an avulsed tooth, allowing pulpal and periodontal healing (19). For an immature tooth with an incomplete root, splinting also retains the tooth in position. Of note, some self-replanted teeth without emergency care and splinting were retained for many years post-avulsion (20, 21). Lack of splinting increases the risk of further trauma and instability during healing. Ideally, a splint should localize the tooth in the original position without further trauma, orthodontic forces or gingival injury, and allow adequate oral hygiene (18, 19, 22). Semi-rigid or flexible splinting allows physiologic tooth movement as functional stimuli assist healing (22–25). A recent evidence-based appraisal of the literature indicated that splint type was not generally a significant variable in relation to healing outcomes (26).

The effect of splinting duration on periodontal healing has not been clarified in clinical studies to date. Long-term splinting may cause ankylosis and replacement resorption (25), but significantly improved outcomes with short-term splinting have not been shown (10, 27–31). The most commonly reported periodontal outcome after replantation is ankylosis (10). A study of 400 avulsed teeth noted decreased frequency of periodontal healing when teeth were splinted for 6 weeks or more; different splint types or splinting periods did not differ significantly (10). Kinirons et al. found significantly more teeth with replacement resorption after long splinting periods (particularly for 11 days or more), and recommended splinting for 10 days or less (32).

It is now recommended that teeth should be splinted for up to 2 weeks rather than 6 weeks as previously (33), and splinting for 1 week may be adequate for periodontal healing (1, 34). The current guidelines for dentists in managing avulsed permanent teeth (excluding root fractures and alveolar fractures) recommend splinting

periods as follows: the International Association of Dental Traumatology, IADT: up to 2 weeks (23, 35); the American Academy of Pediatric Dentistry, AAPD: 7 days (36); the American Academy of Endodontics, AAE: 7–14 days (37, 38); the Royal College of Dental Surgeons England, RCDSE, 7–10 days (24). Acid-etch bonded composite resin splints (e.g., wire-composite), and titanium trauma splints are recommended (17). The IADT guidelines are updated regularly and are available on the IADT webpage (http://www.iadt-dental-trauma.org).

Recommended splinting periods do not distinguish between immature teeth (requiring longer splinting as short roots reduce retention) and teeth with fully-developed apices, nor between immediately-replanted teeth and those replanted after 10 min (where functional periodontal healing is unlikely). Furthermore, recommended splinting periods do not address the tooth storage conditions (storage media, storage time, or dry storage) prior to replantation. If teeth are replanted after an extraoral dry time of 10 min or longer, ankylosis and replacement resorption are likely (10, 39). Recommended splinting periods have been 1 week for teeth with brief extraoral times, 2 weeks for teeth with extraoral times over 60 min, and 4–8 weeks if concurrent alveolar fractures occur (1, 18, 22, 34, 40). Recent guidelines recommend splinting for up to 2 weeks when extraoral dry time is less than 60 min, and for 4 weeks for both immature and mature teeth when extraoral dry times exceed 60 min (35). The splint should be replaced if undue mobility persists after 10 days (24).

The effect of splinting on replacement resorption has been studied in animal models. One dog study suggested splinting may be unnecessary; noting that with a soft diet the periodontal ligament healed and replacement resorption was avoided (41). Studies conducted in monkeys suggested teeth with brief extraoral times benefited from short-term splinting, favorably altering patterns of replacement resorption (25). The extent of replacement resorption in monkey teeth replanted after 18 min related significantly to splinting period; teeth replanted after 120 min dry time showed replacement resorption regardless of splinting period (25). Immediately-replanted monkey teeth splinted for 7 days healed without complications, but teeth splinted for 30 days showed ankylosis and root resorption (42). However, animal studies in which teeth are extracted and then replanted do not replicate the human clinical situation where avulsion occurs in association with a traumatic episode which may cause more extensive injury. Further, animal studies typically have short observational periods, providing cross-sectional information rather than longitudinal data.

In the current era advocating evidence-based research to support clinical guidelines (43), it is noted that only one systematic review appears to have been conducted on clinical studies addressing splinting (26). Randomized controlled clinical trials (RCTs) provide the best evidence, forming the gold standard for evidence-based practice (44). Systematic reviews, searching the literature widely to answer a focused research question and combine RCT results, constitute the highest level of evidence. After retrieval and appraisal, studies included must meet specific criteria for quality and methodology (44, 45). Meta-analyses which pool data from different studies may reveal statistically significant relationships not found in individual studies due to small sample sizes (45).

This paper reports a qualitative systematic review of the literature on splinting duration (14 days or less, or over 14 days) and periodontal healing outcomes, identifies current shortcomings in studies, and makes recommendations for future studies so that questions of splinting duration can be addressed and clinical guidelines established more definitively.

Materials and methods

The PICO question

Evidence-based studies use a PICO question, which in this study was: P (problem): for a replanted avulsed permanent tooth; I (intervention): is short-term splinting (14 days or less); C (comparator): compared with long-term splinting (over 14 days); O (outcome): associated with an increased likelihood of successful periodontal healing? A cutoff point of 14 days was selected to accommodate collectively the current splinting guidelines of the IADT, AAPD, AAE, and RCDSE (23, 24, 35–38).

The literature search

A search performed across four databases [Ovid Medline (46), Cochrane Library (47), PubMed (48), ISI Web of Science (49)], for citations relevant to the PICO question resulted in 36 470 citations (Table 1). The keywords/combinations were: dental/oral trauma, avulsed tooth/teeth, incisor/tooth avulsion, tooth reimplantation/replantation, tooth avulsion AND reimplantation, splinting, tooth splinting, tooth avulsion AND splinting, dental trauma AND splinting, oral trauma AND splinting, tooth reimplantation AND splinting, avulsion AND resorption, tooth avulsion AND resorption, reimplantation AND resorption, tooth reimplantation AND resorption. The steps and procedures have been described previously (50). Limiting the search to papers written in English and deleting duplicates reduced the list to 16 090 citations.

Initial inclusion criteria

Citation titles were included if traumatized permanent teeth identified by the above keywords/combinations were addressed (Table 1).

Exclusion criteria

Citation titles excluded were animal or laboratory studies, studies on primary or posterior teeth, reviews, position papers, letters, editorials, and meeting abstracts. This sieve retained 780 papers; the criteria were re-applied to include abstracts on *avulsion* or *exarticulation* and further exclusion criteria (intentional extraction, transplantation, luxations) were added.

Table 1. Sequence of steps, procedures, and results of evidence-based assessment

Sequence of steps	Procedure	Limitation (inclusion) criteria applied	Results of search and sieve (no. papers)
1. Initial search (Ovid Medline, PubMed, Cochrane Library, ISI Web of Science)	Keywords Boolean operators	Traumatized permanent teeth	36 470
2. Initial removal of duplicate citations	Keywords Boolean operators	Written in English No duplicate citations across database results	22 978
3. Development of single set of citations	Search strings Keywords Boolean operators	No duplicate citations in database results	16 090
4. Preliminary sieve	Paper titles examined	Human studies Actual studies Permanent anterior teeth Relevant to PICO question	780
5. Secondary sieve	Abstracts examined	Above criteria reapplied Clinical studies and case series	89
6. Appraisal and ranking of evidence	Papers examined	Relevant prospective and retrospective clinical studies	34
7. Final assessment	Data extraction and critical appraisal	Short- and long-term splinting in same study	3 (4*)

*One additional paper found through hand searching reference lists.

The evidence hierarchy

Evidence categories were assigned based on abstracts, ranking papers as: (i) clinical studies, (ii) case series, (iii) case reports, (iv) opinion articles/position papers, (v) reviews, (vi) irrelevant articles and (vii) gray literature (inaccessible through the available databases or libraries). For articles without abstracts, the *introduction* and *materials and methods* sections were read to determine study relevance and assign an evidence category. Examining titles and abstracts of the 780 papers we found 314 were irrelevant and 144 were case reports; 89 papers (68 clinical studies, 21 case series) were retained (Table 1).

Appraisal and ranking of evidence

Appraisal recognized that few papers addressed the aims of the present study and that data were derived from studies conducted for other aims. Full texts of all 89 papers were examined and the reference lists were checked for relevant additions; 34 papers described 31 prospective or retrospective clinical studies and one paper was added (Table 1). A study of these 90 papers found 52 were irrelevant (one position paper; one on prevalence; 23 on trauma but not avulsion; five on intentional extraction/transplantation; one on risk factors; one on splint design; 17 case reports, three case series), and three were gray literature. Data extracted from the remaining 39 papers were appraised using a form adapted from checklists (51–54). Excluded then were 31 papers describing clinical studies (21 omitted splinting duration; three omitted comparative groups; one on pulp healing; two with extraoral endodontic therapy before replantation; four addressed a prospective cohort study with splinting periods outside the clinical guidelines).

Final inclusion criteria

The final inclusion criteria for papers required details of: case selection, initial sample size, withdrawals, evaluator blinding, sizes of intervention and comparison groups, periodontal healing outcomes described in relation to emergency treatment, and splinting duration. As some relevant studies were excluded due to insufficient detail, attempts were made to contact the authors of 10 papers by email. No extra information became available: four authors said the data were stored and unavailable, four did not respond and two could not be contacted.

Results

Studies investigating effects of splinting duration

Four retrospective (27–30) and four prospective studies (10, 31, 32, 55) investigated splinting periods in relation to periodontal healing outcomes, using criteria (Table 2). Retrospectively following 110 teeth splinted for periods of 1 week to 4 months, Andreasen & Hjörting-Hansen found no correlation between fixation and replantation outcomes (27). Studying 21 teeth splinted for 9–45 days, Andersson & Bodin found no relationship between rate of root resorption and splinting period (28). Following 46 teeth in 6–14 year-olds splinted for 1–2 weeks, Mackie & Worthington found no differences in success rates for splint types or splinting periods (29). Observing 34 teeth for at least 1 year, Sae-Lim & Yuen concluded the effect of splinting period was not as important as other factors studied (30).

In prospective studies, Andreasen et al. (10) reported that splinting periods of 40 days or more resulted in less frequent periodontal healing (not statistically significant) than shorter periods (Table 2). Kinirons et al. reported an odds ratio for resorption of 1.08 (95% CI = 0.90–1.24) for each extra day of splinting, suggesting a small (statistically nonsignificant) increase in the likelihood of resorption for each day the splint was in place (31). Kinirons et al. reported a very low prevalence of resorption in teeth splinted for 4–10 days, but little difference between those splinted for 11–19 days or 20 days or more (32). Andreasen tabulated data on

Table 2. Descriptions of eight studies reporting effects of splinting periods on periodontal healing outcomes

Study and study type	No. patients	Patient age (years)	No. teeth	Splinting period	Follow-up	Diagnosis of periodontal healing outcome
Retrospective clinical audits						
Andreasen & Hjörting-Hansen (27)	82	6–24	110	1 week to 4 months	2 months to 40 years	Radiographic, high percussion note, reduced mobility, infraocclusion
Andersson & Bodin (28)	18	7–29	21	9–45 days	Av 5 years	Radiographic (root resorption index)
Mackie & Worthington (29)	36	6–14	46	1–2 weeks	1–7 years	Radiographic, high percussion note, reduced mobility, infraocclusion
Sae-Lim & Yuen (30)	Not given	7–48	34	≤14 days: 8 ≥14 days: 26	Min 1 year	Radiographic
Prospective clinical studies						
Andreasen et al. (10)	322	5–52	400	≤20 days: 135 21–40 days: 39 ≥40 days: 93	Up to 20 years	Radiographic, clinical evaluation
Kinirons et al. (31)	109	7–18	129	4–52 days	Min 2 years	Radiographic, high percussion note, no mobility, clinical ankylosis
Kinirons et al. (32)	71	6–16	84	4–10 days: 24 11–19 days: 33 ≥20 days: 27	Min 2 years	Radiographic, high percussion note, reduced mobility, periodontal ligament space loss
Andreasen (55)	35	7–39	40	1–12 weeks	Up to 1 year	Radiographic (resorption), mobility, percussion

healing outcomes for 40 replanted permanent incisors splinted for 1–12 weeks (55).

Not shown in Table 2, two further studies reported splinting outcomes but combined results for avulsed teeth with other luxation injuries (56, 57). Oikarinen et al. reported splinting period was a more decisive cause of external root resorption than tooth maturity or luxation type (56), whereas Crona-Larsson et al. observed no difference in post-traumatic healing in relation to splinting duration (57).

Direct comparisons of short-term and long-term splinting

Only studies reporting splinting periods according to current guidelines of the IADT, AAPD, AAE, and RCDSE (23, 24, 35–38) were included. Four papers (28, 30, 32, 55) provided data directly comparing short-term splinting (ST, 14 days or less) and long-term splinting (LT, over 14 days) in relation to periodontal healing outcomes (Table 3). Favorable periodontal healing outcomes were defined for the present study as: no resorption (28), non-progressive resorption (28), positive periodontal outcome (30), no replacement resorption (32), normal healing (55), and transient replacement resorption (55).

Some teeth were excluded in the present study due to insufficient data on splinting periods or healing outcomes (28, 55), or misfit of splinting period (11–19 days) (32), reducing sample sizes. A total of 138 teeth (ST splinting: 66; LT splinting: 72) were pooled (Table 3). After ST splinting, favorable periodontal outcomes varied widely between studies: 3/4 teeth (28), 2/8 teeth (30), 20/24 teeth (32), 8/30 teeth (55); total 33/66 (50%). After LT splinting, favorable periodontal outcomes also varied widely between studies: 9/13 teeth (28), 10/26 teeth (30), 11/27 teeth (29), 2/6 teeth (52); total 32/72 (44%).

Periodontal healing outcomes

In order to pool teeth from several studies, terminology differences (Table 3) dictated re-classification of periodontal healing outcomes into three outcome categories:

Table 3. Periodontal healing outcomes in four studies reporting on short-term and long-term splinting

Study and study type	Number of teeth	Short-term splinting (no. teeth)	Periodontal healing outcome after short-term splinting (no. teeth)	Long-term splinting (no. teeth)	Periodontal healing outcome after long-term splinting (no. teeth)
Retrospective clinical audits					
Andersson & Bodin (28)	17	4	No resorption (2) Non-progressive resorption (1) Progressive resorption (1)	13	No resorption (4) Non-progressive resorption (5) Progressive resorption (4)
Sae-Lim & Yuen (30)	34	8	Positive periodontal outcome (2) Negative periodontal outcome (6)	26	Positive periodontal outcome (10) Negative periodontal outcome (16)
Prospective clinical studies					
Kinirons et al. (32)	51	24	No replacement resorption (20) Replacement resorption (4)	27	No replacement resorption (11) Replacement resorption (16)
Andreasen (55)	36	30	Normal healing (4) Transient replacement resorption (4) Permanent replacement resorption (20) Inflammatory resorption (2)	6	Transient replacement resorption (2) Inflammatory resorption (4)
Total	138	66		72	

(i) functional healing, (ii) acceptable healing, and (iii) development of replacement resorption. A negative periodontal outcome was defined by Sae-Lim & Yuen (30) as: ankylosis/replacement resorption, inflammatory resorption, marginal periodontal breakdown, and progressive resorption (Table 3).

Functional healing was defined as: no root resorption (28), intact periodontal ligament space (30), slightly increased or normal mobility (55), and no radiographic sign of progressive root resorption (55). Functional healing was determined from data in three studies (28, 30, 55; Table 3), pooling 87 teeth (ST splinting: 42; LT splinting: 45). Functional healing occurred as follows: ST splinting: 8/42 teeth (19%); LT splinting: 14/45 teeth (31%).

Acceptable healing was defined as: no root resorption or some non-progressive root resorption (28), intact periodontal ligament space (30), no replacement resorption (32), and some transient replacement resorption (55). Acceptable healing was determined from data in four studies (28, 30, 32, 55; Table 3), pooling 138 teeth (ST splinting: 66; LT splinting: 72). Acceptable healing occurred as follows: ST splinting: 33/66 teeth (50%); LT splinting: 32/72 teeth (44%).

Development of replacement resorption was defined as: replacement resorption (32) and permanent replacement resorption (55). Two studies (32, 55) described replacement resorption (Table 3), providing 87 teeth (ST splinting: 54; LT splinting: 33). Replacement resorption occurred as follows: ST splinting: 24/54 teeth (44%); LT splinting: 16/33 teeth (48%).

Discussion

Based on an evidence-based assessment of four papers reporting clinical studies on 138 replanted permanent teeth splinted according to current clinical guidelines (66 teeth for 14 days or less, 72 for more than 14 days), the present study suggests that the likelihood of successful periodontal healing after replantation is unaffected by splinting duration, supporting other reports (10, 26–31). Andreasen et al. (10) found that splinting for 6 weeks or more resulted in lower frequency of healing, supporting splinting for up to 40 days. This large study (10) was not included in the present study as the splinting periods (≤20 days, 21–40 days, ≥40 days) could not be adapted to fit within the selected classification by clinical guidelines of 14 days or less and more than 14 days (23, 24, 35–38). However, the observations of Andreasen et al. (10) were confirmed by the present study. Kinirons et al. (32) showed a low prevalence of resorption in teeth splinted for 10 days or less, supporting current guidelines. Vitality of periodontal ligament cells (strongly affected by extraoral time and storage conditions) may have a greater effect on functional healing than splinting period (58).

A recent retrospective case audit of 100 replanted avulsed permanent teeth showed root replacement resorption (ankylosis) is the most frequent periodontal complication of replantation, occurring in 41% of cases (59). In the present study, development of replacement resorption occurred in 44% of the pooled sample receiving short-term splinting and in 48% of the pooled sample receiving long-term splinting. Transient replacement resorption may reflect slow replacement resorption, affected by factors such as metabolic rate, rate of physiologic bone turnover and patient age (1, 60). If replacement resorption develops in all teeth with extended extraoral times, the effect of splinting period on replacement resorption must be separated from the effect of extraoral time. Due to lack of data in papers examined for the present study, teeth could not be sorted by extraoral time to control for detrimental effects on periodontal ligament cells. Future studies of teeth replanted immediately with vital periodontal ligament cells could reveal a true effect of long splinting periods on development of replacement resorption.

Different splinting periods may reflect clinical or developmental factors necessitating early/late splint removal, altering outcomes. For example, teeth with immature short roots, horizontal root fractures or alveolar bone fractures may require splinting beyond 14 days to ensure stability. Noting similar outcomes for periodontal healing with splinting for more or less than 14 days, dentists can be reassured in such splinting. However, plaque buildup, difficult oral hygiene, esthetics, and patient comfort must be considered in long-term splinting.

As many factors may contribute to post-replantation complications, separation of favorable periodontal healing outcomes (functional healing, acceptable healing) from complications (replacement resorption, inflammatory resorption) was attempted in the present study, limiting the pooling of studies. Variations in periodontal healing outcomes and terminology were noted between studies, necessitating some assumptions. For example, one healing outcome has been described in different terms: Sae-Lim & Yuen (30) used the term 'positive periodontal outcome' whereas Andersson & Bodin (28) reported 'no root resorption'. Variable interpretation of terminology introduces inaccuracy in combining studies. Differing definitions have been also noted in other systematic reviews (45).

Combining complications by outcomes such as 'negative periodontal healing' or 'progressive root resorption' made it difficult to determine the presence or absence of healing outcomes such as replacement resorption. Studies combining all negative outcomes together were precluded from the present study, reducing the number of teeth available. Standardized terminology for periodontal healing outcomes would aid future comparisons and analyses.

The few studies fulfilling the inclusion criteria markedly limited the pooled sample sizes in the present paper. For example, missing details on splint types (e.g., rigid or flexible) required the assumption that all splints had a similar effect on teeth over similar time periods. However, different outcomes have been shown between splint types. For example, an autotransplantation study of third molar tooth germs transplanted to replace missing premolars found rigid fixation for 4 weeks with acid-etch composite and wire splints resulted in significantly more teeth with ankylosis than when transplants were stabilized with suture splints for 1 week (61). This finding is of

particular interest as the major confounder of extraoral dry time was controlled. Tooth storage media, storage time, tooth development, and tooth pre-treatment prior to replantation (e.g., antibiotic solution applied to the root surface) were described rarely in papers examined in the present study and therefore could not be used as inclusion or exclusion criteria in selecting studies. Further, random allocation of splinting periods was not described in any of the selected papers.

Clinical studies on replanted teeth take a long time to accumulate sample sizes sufficient for statistical analysis. Future meta-analyses of pooled results from multiple studies with similar data collection methods could overcome these problems. Using standardized data collection forms completed and accessed electronically would assist data compilation from several institutions, allowing many teeth to be analyzed in a multi-center approach (62). Structured recording of management of traumatized teeth on international databases common to major dental trauma institutions is indicated.

The lack of RCTs of replanted teeth limited the present study which was based upon studies not providing the highest level of evidence. However, RCTs assessing the effect of interventions prospectively are complicated by many uncontrollable variables and ethics approval for such studies would be unlikely. Instead, prospective cohort studies could serve as the highest level of evidence for replantation studies, but including these in meta-analyses has been debated (63, 64). A confounder in one cohort study may occur across several studies; on combination the increased risk seen may be associated actually with the confounder rather than the intervention, thereby invalidating the meta-analyses (63, 65).

Including retrospective cohort studies is a limitation of the present study. Retrospective audits from institutions with established emergency trauma assessment forms and standardized management protocols would provide stronger evidence than retrospective audits from institutions without such protocols. Data collection forms and standardized trauma protocols have been described and used prospectively in studying factors that should be recorded at initial presentation (66).

A systematic review is only as thorough as the underlying research. The present study sought objectivity, defining selection criteria and using data extraction and appraisal forms. Assessor subjectivity may bias systematic reviews and two or more assessors are recommended to minimize bias in paper selection and criteria application. Papers in languages other than English or located by other databases (options which were unavailable to the present authors) could have provided additional teeth for study.

Meta-analyses of data in the present study were not possible due to the very small sample sizes and the obvious dissimilarities of selected studies in their design, methodology and observation periods. In particular, the studies did not utilize identical terminology for periodontal healing outcomes. This is not surprising as most studies were retrospective reports of clinical outcomes based on case audits, rather than prospectively designed studies with splinting as a dependent variable.

This study of the splinting periods in current guidelines (23, 24, 35–38) suggests that the collected evidence from studies of replanted permanent teeth is inconclusive; the duration of splinting appears unlikely to affect periodontal healing outcomes. As no evidence contraindicates the guidelines, it is recommended that dentists use these splinting periods in managing permanent avulsed teeth.

Conclusion

This qualitative systematic review of splinting duration and periodontal healing outcomes, based on a sample of 138 replanted avulsed permanent teeth pooled from four papers each reporting both short-term splinting (14 days or less) and long term-splinting (over 14 days), suggests that the likelihood of successful periodontal healing after replantation is unaffected by splinting duration. The evidence for an association between short-term splinting and an increased likelihood of functional periodontal healing, an acceptable healing outcome, or decreased development of replacement resorption appears inconclusive. Pending future research to the contrary, it is recommended that dentists continue to use the currently recommended splinting periods in managing replanted permanent teeth.

References

1. Andreasen JO, Andreasen FM. Textbook and colour atlas of traumatic injuries to the teeth, 3rd edn. Copenhagen: Munksgaard; 1994. pp. 155, 383–425.
2. Andersson L. Editorial: Tooth avulsion and replantation. Dent Traumatol 2007;23:129.
3. Loe H, Waerhaugh J. Experimental replantation of teeth in dogs and monkeys. Arch Oral Biol 1961;3:176–84.
4. Hammer JE III, Reed OM, Stanley HR. Reimplantation of teeth in the baboon. J Am Dent Assoc 1970;81:662–70.
5. Van Hassel HJ, Oswald RJ, Harrington GW. Replantation: the role of the periodontal ligament. J Endod 1980;6:506–8.
6. Blomlöf L, Lindskog S, Andersson L, Hedström KG, Hammerström L. Storage of experimentally avulsed teeth in milk prior to replantation. J Dent Res 1983;62:912–6.
7. Hammerström LE, Blomlöf LB, Feiglin B, Lindskog SF. Effect of calcium hydroxide treatment on periodontal repair and root resorption. Endod Dent Traumatol 1986;2:184–9.
8. Wong KS, Sae-Lim V. The effect of intracanal Ledermix on root resorption of delayed-replanted monkey teeth. Dent Traumatol 2002;18:309–15.
9. Andreasen JO. Periodontal healing after replantation and autotransplantation of incisors in monkeys. Int J Oral Surg 1981;10:54–61.
10. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. 4. Factors related to periodontal ligament healing. Endod Dent Traumatol 1995;11:76–89.
11. Kenny DJ, Barrett EJ. Recent developments in dental traumatology. Pediatr Dent 2001;23:464–8.
12. Hamilton FA, Hill FJ, Holloway PJ. An investigation of dentoalveolar trauma and its treatment in an adolescent population. Part 2: dentists' knowledge of management methods and their perceptions of barriers to providing care. Br Dent J 1997;182:129–33.
13. Kahabuka FK, Ntaabaye MK, van't Hof MA, Plasschaert A. Effect of a consensus statement for traumatic dental injuries. Dent Traumatol 2001;17:159–62.

14. Kostopoulou MN, Duggal MS. A study into dentists' knowledge of the treatment of traumatic injuries to young permanent incisors. Int J Paediatr Dent 2005;15:10–9.
15. Kahabuka FK, Willemsen W, van't Hof M, Ntabaye MK, Burgersdijk R, Frankenmolen F et al. Initial treatment of traumatic injuries by dental practitioners. Endod Dent Traumatol 1998;14:206–9.
16. Dorney B. Inappropriate treatment of traumatic dental injuries. Aust Endod J 1999;25:76–8.
17. Flores MT, Andersson L, Andreasen JO, Bakland LK, Malmgren B, Barnett F et al. Guidelines for the management of traumatic dental injuries. I. Fractures and luxations of permanent teeth. Dent Traumatol 2007;23:66–71.
18. Trope M. Clinical management of the avulsed tooth. Present strategies and future directions. Dent Traumatol 2002;18:1–11.
19. Oikarinen K. Tooth splinting: a review of the literature and consideration of the versatility of a wire composite splint. Endod Dent Traumatol 1990;6:237–50.
20. Fuss Z. Successful self-replantation of avulsed tooth with 42-year follow-up. Endod Dent Traumatol 1985;1:120–2.
21. Abbott P. Self-replantation of an avulsed tooth: 30-year follow-up. Int Endod J 1991;24:36–40.
22. Ram D, Cohenca N. Therapeutic protocols for avulsed permanent teeth: review and clinical update. Pediatr Dent 2004;26:251–5.
23. Flores MT, Andreasen JO, Bakland LK. Guidelines for the evaluation and management of traumatic dental injuries. Dent Traumatol 2001;17:193–6.
24. Gregg TA, Boyd DH. UK National Clinical Guidelines in Paediatric Dentistry. Treatment of avulsed permanent teeth in children. Int J Paediatr Dent 1998;8:75–81.
25. Andreasen JO. The effect of splinting upon periodontal healing after replantation of permanent incisors in monkeys. Acta Odont Scand 1975;33:313–23.
26. Kahler B, Heithersay GS. An evidence-based appraisal of splinting luxated, avulsed and root-fractured teeth. Dent Traumatol 2008;24:2–10.
27. Andreasen JO, Hjörting-Hansen E. Replantation of teeth. I. Radiographic and clinical study of 110 human teeth replanted after accidental loss. Acta Odontol Scand 1966;24:263–86.
28. Andersson L, Bodin I. Avulsed human teeth replanted within 15 minutes – a long-term clinical follow-up study. Endod Dent Traumatol 1990;6:37–42.
29. Mackie IC, Worthington HV. An investigation of replantation of traumatically avulsed permanent incisor teeth. Br Dent J 1992;172:17–20.
30. Sae-Lim V, Yuen KW. An evaluation of after-office-hour dental trauma in Singapore. Endod Dent Traumatol 1997;13:164–70.
31. Kinirons MJ, Gregg TA, Welbury RR, Cole BOI. Variations in the presenting and treatment features in reimplanted permanent incisors in children and their effect on the prevalence of root resorption. Br Dent J 2000;189:263–6.
32. Kinirons MJ, Boyd DH, Gregg TA. Inflammatory and replacement resorption in reimplanted permanent incisor teeth: a study of the profiles of 84 teeth. Endod Dent Traumatol 1999;15:269–72.
33. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. 1. Diagnosis of healing complications. Endod Dent Traumatol 1995;11:51–8.
34. McDonald N, Strassler HE. Evaluation for tooth stabilization and treatment of traumatized teeth. Dent Clin N Am 1999;43:135–49.
35. Flores MT, Andersson L, Andreasen JO, Bakland LK, Malmgren B, Barnett F et al. Guidelines for the management of traumatic dental injuries. II. Avulsion of permanent teeth. Dent Traumatol 2007;23:130–6.
36. American Academy of Pediatric Dentistry. Clinical guideline on management of acute dental trauma. Pediatr Dent 2005;27:120–5.
37. Pavek DI, Radtke PK. Post-replantation management of avulsed teeth: An endodontic literature review. Gen Dent 2000;48:176–81.
38. American Association of Endodontists. Recommended Guidelines of the American Association of Endodontists for the treatment of traumatic dental injuries. 2004 http://www.aae.org/dentalpro/EducationalResources/guidelines.htm [accessed on 15 December 2007].
39. Barrett EJ, Kenny DJ. Avulsed permanent teeth: a review of the literature and treatment guidelines. Endod Dent Traumatol 1997;13:153–63.
40. Trope M. Treatment of the avulsed tooth. Pediatr Dent 2000;22:145–7.
41. Wallace JA, Vergona K. Epithelial rests' function in replantation: is splinting necessary in replantation? Oral Surg Oral Med Oral Pathol 1990;70:664–9.
42. Nasjlete CE, Castelli WA, Caffesse RG. The effects of different splinting times on replantation of teeth in monkeys. Oral Surg Oral Med Oral Pathol 1982;53:557–66.
43. Sutherland SE, Matthews DC, Fendrich P. Clinical practice guidelines in dentistry: Part II. By dentists, for dentists. J Can Dent Assoc 2001;67:448–52.
44. Sackett DL. Rules of evidence and clinical recommendations. Can J Cardiol 1993;9:487–9.
45. Sutherland SE, Matthews DC. Conducting systematic reviews and creating clinical practice guidelines in dentistry. Lessons learned. J Am Dent Assoc 2004;135:747–53.
46. Ovid Medline Library. http://portal.isiknowledge.com.ezproxy.lib.unimelb.edu.au/portal.cgi/portal.cgi?DestApp=MEDLINE [accessed on 15 December 2007].
47. Cochrane Library. http://www3.interscience.wiley.com/cgi-bin/mrwhome/106568753/HOME [accessed on 15 December 2007].
48. PubMed. http://www.ncbi.nlm.nih.gov/sites/entrez [accessed on 15 December 2007].
49. ISI Web of Science. http://isiwebofknowledge.com/ [accessed on 15 December 2007].
50. Loh A, O'Hoy P, Tran X, Charles R, Hughes A, Kubo K et al. Evidence-based assessment: evaluation of the formocresol versus ferric sulfate primary molar pulpotomy. Pediatr Dent 2004;26:401–9.
51. CASP Critical Appraisal Skills Program. http://www.phru.nhs.uk/Pages/PHD/resources.htm [accessed on 15 December 2007].
52. Ottawa Health Research Institute. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analyses. http://www.ohri.ca/programs/clinical_epidemiology/oxford.htm [accessed on 15 December 2007].
53. Health evidence bulletins Wales appraisal checklist. http://hebw.cf.ac.uk/projectmethod/project%20Methodology%205.pdf [accessed on 15 December 2007].
54. NHMRC. How to use the evidence: assessment and application of scientific evidence. http://www.nhmrc.gov.au/publications/-files/cp69.pdf [accessed on 15 December 2007].
55. Andreasen JO. Periodontal healing after replantation of traumatically avulsed human teeth. Assessment of mobility testing and radiography. Acta Odontol Scand 1975;33:325–35.
56. Oikarinen K, Gundlach KKH, Pfeifer G. Late complications of luxation injuries to teeth. Endod Dent Traumatol 1987;3:296–303.
57. Crona-Larsson G, Bjarnason S, Noren JG. Effect of luxation injuries on permanent teeth. Endod Dent Traumatol 1991;7:199–206.
58. Lekic PC, Kenny DJ, Barrett EJ. The influence of storage conditions on the clonogenic capacity of periodontal ligament cells: implications for tooth replantation. Int Endod J 1998;31:137–40.
59. Soares Ade J, Gomes BP, Zaia AA, Ferraz CC, de Souza-Filho FJ. Relationship between clinical-radiographic evaluation and outcome of teeth replanation. Dent Traumatol 2008;24:183–8.

60. Tronstad L. Root resorption-etiology, terminology and clinical manifestations. Endod Dent Traumatol 1988;4:241–52.
61. Bauss O, Schilke R, Fenske C, Engelke W, Kiliaridis S. Autotransplantation of immature third molars: influence of different splinting methods and fixation periods. Dent Traumatol 2002;18:322–8.
62. Day PF, Duggal MS. A multicentre investigation into the role of structured histories for patients with tooth avulsion at their initial visit to a dental hospital. Dent Traumatol 2003;19:243–7.
63. Shapiro S. Meta-analysis/Schmeta-analysis. Am J Epidemiol 1994;140:771–8.
64. Petitti D. Of babies and bathwater. J Epidemiol 1994;140:779–82.
65. Lecky FE, Little RA, Brennan P. The use and misuse of meta-analysis. J Accid Emerg Med 1996;12:373–8.
66. Barrett EJ, Kenny DJ. Survival of avulsed permanent maxillary incisors in children following delayed replantation. Endod Dent Traumatol 1997;12:269–75.