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Lateral Alveolar Ridge Augmentation with Autogenous Tooth Block Graft Compared with Autogenous Bone Block Graft: a Systematic Review

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ABSTRACT

Objectives: The objective of the present systematic review was to evaluate the current knowledge of implant treatment outcome following lateral alveolar ridge augmentation with autogenous tooth block graft compared with autogenous bone block graft prior to implant placement.
Material and Methods: MEDLINE (PubMed), Embase and Cochrane Library search in combination with hand-search of relevant journals was conducted including human studies published in English through December 20, 2021. Comparative and non-comparative studies assessing lateral alveolar ridge augmentation with autogenous tooth block graft were included. Quality and risk-of-bias assessment were evaluated by Cochrane risk of bias tool, Newcastle-Ottawa Scale and GRADE system.
Results: One comparative study characterized by low grade and two non-comparative studies fulfilled the inclusion criteria. No significant difference in short-term implant survival, health status of the peri-implant tissue or frequency of complications between the two treatment modalities was observed. Postoperative dimensional changes of the alveolar ridge width were significant diminished with tooth block compared with bone block ($P = 0.0029$). Consequently, the gain in alveolar ridge width was significantly higher with tooth block, after 26 weeks ($P = 0.014$). However, a higher frequency of short-term peri-implant mucositis was observed with tooth block.
Conclusions: Lateral alveolar ridge augmentation with tooth block seems to be a suitable alternative to bone block. However, results of the present systematic review are based on short-term studies involving small patient samples. Further long-term randomized controlled trials are therefore needed before definite conclusions can be provided about the beneficial use of tooth block compared with bone block.

Keywords: alveolar bone grafting; alveolar ridge augmentation; dental implants; oral surgical procedures; review.

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INTRODUCTION

Horizontal alveolar ridge deficiency following tooth loss, trauma or long-term edentulism adversely affects optimal dental implant positioning [1]. Lateral alveolar ridge augmentation (LARA) prior to placement of implants is therefore often necessary when the dimensions of the alveolar process prevent implant placement in a prosthetically ideal position. LARA with a mono-cortical autogenous bone block graft harvested from the ascending mandibular ramus or the mandibular symphysis is the most used surgical procedure to obtain sufficient width of the alveolar ridge prior to implant placement. High survival rate of suprastructures and implants, limited peri-implant marginal bone loss, adequate width gain of the alveolar ridge and few complications have been reported in long-term studies and systematic reviews following LARA with an autogenous bone block graft [2-9]. However, harvesting of an autogenous bone block graft is associated with risk of donor site morbidity, unpredictable graft resorption and possibility of injury to neighboring vital structures [10-13]. Various allogeneic, xenogeneic, and alloplastic bone blocks materials have therefore been used for reconstruction of alveolar ridge deficiencies to simplify the surgical procedure and avoiding harvesting of an autogenous bone block graft. However, the use of allogeneic or xenogeneic bone block materials are associated with a significant higher frequency of complications compared with an autogenous bone block graft including infection, wound dehiscence, implant losses, partially or completely exfoliation of the grafting material combined with a risk of immunologic reactions or disease transmission [14-17]. Consequently, LARA with the use of an autogenous bone block graft is therefore still considered as the golden standard for reconstruction of substantial alveolar ridge deficiencies prior to implant placement despite the disadvantage associated with the harvesting procedure.

Autogenous teeth have a structural composition and physicochemical features like alveolar cortical bone [18-20]. Reconstruction of alveolar deficiencies with the use of an autogenous tooth block graft prior to implant placement have therefore been proposed as an alternative grafting material to the traditional use of an autogenous bone block graft [21-23]. The efficacy of autogenous teeth as grafting material has previously been assessed in systematic reviews concluding that autogenous teeth can be used as an alternative grafting material for reconstruction of alveolar ridge deficiencies prior to or in conjunction with placement of implants [24,25]. However, LARA with the use of an autogenous tooth block graft compared with autogenous bone block graft prior to placement of implants have never previously been specifically assessed in a systematic review. The objective of the present systematic review is therefore to evaluate the current knowledge of implant treatment outcome following lateral alveolar ridge augmentation with an autogenous tooth block graft compared with autogenous bone block graft.

MATERIAL AND METHODS

Protocol and registration

The present systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement for reporting systematic reviews [26]. The methods of the analysis and inclusion criteria were specified in advance and documented in a protocol and registered in PROSPERO, an international prospective register of systematic reviews.

Registration number: CRD42022299935

The protocol can be accessed at:
https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022299935.

Focus question

The focus question was created according to the Patient, Intervention, Comparison and Outcome (PICO) framework as described in Table 1.

Eligibility criteria for considering studies for this review

Randomized controlled trials, controlled clinical trials, case-series and retrospective human studies assessing implant treatment outcome following LARA with an autogenous tooth block graft compared with autogenous bone block graft were included. Human studies solely evaluating LARA with an autogenous tooth block graft were included as non-comparative studies.

Types of outcome measures

- Survival of suprastructures. Estimated by subtracting of failed suprastructures, which is defined as a complete loss of the suprastructure due to technical and/or biological complications.

Table 1. PICOS guidelines

Patient and population (P)	Healthy patients with a horizontal alveolar deficiency following tooth loss, trauma or congenitally missing tooth/teeth.
Intervention (I)	Lateral alveolar ridge augmentation with an autogenous tooth block graft.
Comparator or control group (C)	Lateral alveolar ridge augmentation with an autogenous bone block graft.
Outcomes (O)	Survival of suprastructures, survival of implants, implant stability quotient, health status of the peri-implant tissue, gain in alveolar ridge width, postoperative dimensional changes of the alveolar ridge, patient-reported outcome measures, biologic and technical complications.
Study design (S)	Randomized controlled trials, controlled clinical trials, case-series and retrospective studies assessing lateral alveolar ridge augmentation with an autogenous tooth block graft compared with autogenous bone block graft. Moreover, human studies solely assessing lateral alveolar ridge augmentation with an autogenous tooth block graft were included as non-comparative studies.
Focused question	Are there any differences in implant treatment outcome following lateral alveolar ridge augmentation with an autogenous tooth block graft compared with autogenous bone block graft?

- Survival of implants. Estimated by subtracting of failed implants, which is defined as mobility of previously clinically osseointegrated implants or removal of non-mobile implants due to progressive peri-implant marginal bone loss or infection.
- Implant stability. Estimated by magnetic resonance frequency analysis, percussion test or reverse torque test.
- Health status of the peri-implant tissue (HSPIT). Bleeding on probing, probing depth, mucosal recession, clinical attachment level and peri-implant marginal bone level as evaluated by clinical and radiographic measurements.
- Gain in alveolar ridge width. Estimated by clinical or radiographic measurements.
- Postoperative dimensional changes of the alveolar ridge width. Estimated by clinical or radiographic measurements.
- Patient-reported outcome measures.
- Biologic and technical complications.

Information sources

The search strategy incorporated examinations of electronic databases, supplemented by a thorough hand-search page by page of relevant journals including "British Journal of Oral and Maxillofacial Surgery", "Clinical Implant Dentistry and Related Research", "Clinical Oral Implants Research", "European Journal of Oral Implantology", "Implant Dentistry", "International Journal of Oral and Maxillofacial Implants", "International Journal of Oral and Maxillofacial Surgery", "International Journal of Periodontics and Restorative Dentistry", "International Journal of Prosthodontics", "Journal of Clinical Periodontology", "Journal of Dental Research", "Journal of Oral Implantology", "Journal of Oral & Maxillofacial Research", "Journal of Periodontology", "Journal of Prosthetic Dentistry", "Journal of Craniofacial Surgery", "Journal of Cranio-Maxillo-Facial Surgery", "Journal of Oral and Maxillofacial Surgery", "Periodontology 2000", "Oral and Maxillofacial Surgery" and "Oral Surgery Oral Medicine Oral Pathology Oral Radiology". The manual search also included the bibliographies of all articles selected for full-text screening as well as previously published reviews relevant for the present systematic review. Two reviewers (J.V. and K.B.Ø.) independently performed the search. In the event of disagreement, another reviewer was consulted (T.S-J.)

Search strategy for identification of studies

A MEDLINE (PubMed), Embase, and Cochrane Library search was conducted. Human studies published in English through December 20, 2021 were included. Grey literature, unpublished literature as well as other databases like Scopus, Google Scholar, or Research Gate were not included in the search strategy of the present systematic review. Search strategy was performed in collaboration with a librarian and utilized a combination of Medical subject heading (MeSH) and free text terms. A detailed description of the search strategy is presented in Appendices 1 to 4.

Selection of studies

PRISMA flow diagram presents an overview of the selection process (Figure 1). Titles of identified reports were initially screened with duplicates removed. Abstracts were assessed when titles indicated that the study was relevant. Full-text analysis was obtained for those with apparent relevance or when the abstract was unavailable.

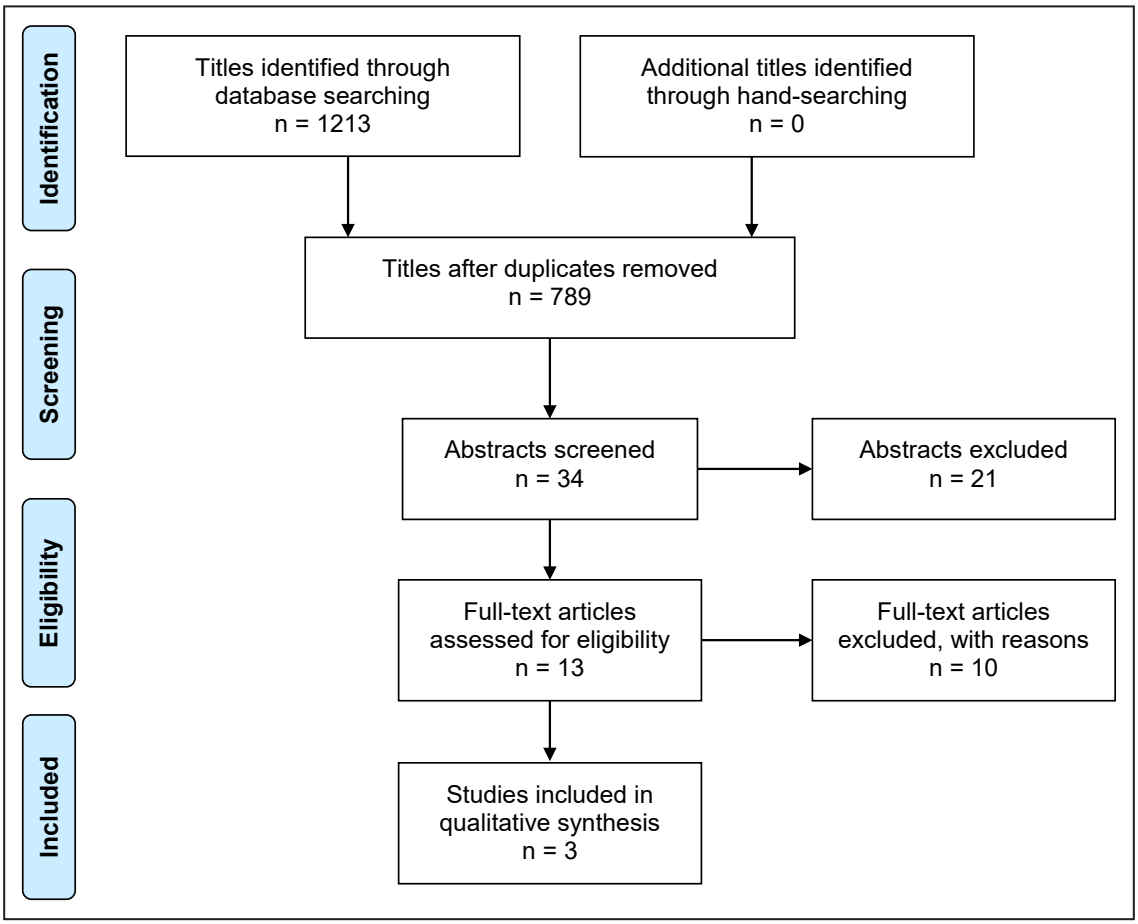

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram demonstrating results of systematic literature search. Electronic search resulted in 1213 entries. No articles were identified through hand-searching. Of these 1213 articles, 424 were excluded because they had been retrieved in more than one search. A total of 34 abstracts were reviewed and full-text analysis included 13 articles. Three studies were finally included comprising one comparative study and two non-comparative studies.

References of papers identified and previously published systematic reviews assessing reconstruction of alveolar ridge deficiencies with an autogenous tooth as grafting material were cross-checked for unidentified articles. Study selection was performed by two reviewers (J.V. and K.B.Ø.). In the event of disagreement between the reviewers, another reviewer was consulted (T.S-J.). The level of agreement between the reviewers was tested using the Cohen´s kappa coefficient (k).

Inclusion criteria

Studies assessing implant treatment outcome following LARA with an autogenous tooth block graft compared with autogenous bone block graft were included by addressing the previously described outcome measures. The review exclusively focused on studies using LARA with an autogenous tooth block graft and lag-screw fixation prior to implant placement. In addition, at least five patients should be included, and number of inserted implants and surgical procedures had to be clearly specified.

Exclusion criteria

Following exclusion criteria were applied: unspecified length of observation period, insufficient description of the surgical procedure or number of inserted implants as well as studies involving medically compromised patients. Studies assessing the autogenous dentin shell graft technique or particulated autogenous tooth material in conjunction with delayed or simultaneous placement of implants were excluded as well as letters, editorials, PhD theses, letters to the editor, case reports, abstracts, technical reports, conference proceedings, cadaveric studies, animal or *in vitro* studies and literature review papers.

Data extraction

Data were extracted by one reviewer (T.S-J.) according to a data-collection form ensuring systematic recording of the outcome measures. In addition, relevant characteristics of the study were recorded. Corresponding authors were contacted by e-mail in the absence of important information or ambiguities.

Data items

Following items were collected and arranged in following fields: author, number of patients, type of bone defect, type of grafting material, thickness of the grafting material, graft healing period, number of inserted implants, observation period after functional implant loading, implant stability quotient, survival of suprastructure and implant, HSPIT, gain in alveolar ridge width, postoperative dimensional changes of the alveolar ridge width, patient-reported outcome measures (PROM), biologic and technical complications.

Quality and risk-of-bias assessment

Quality assessment was undertaken by one review author (T.S-J.) as part of the data extraction process. Cochrane Collaboration's tool for assessing the risk of bias suggested in the Cochrane Handbook for Systematic Reviews of Interventions was used for included randomized controlled trials (version 5.1.0) [27]. Following items were evaluated:

- Random sequence generation;
- Allocation concealment;
- Patient blinding;
- Outcome blinding;
- Incomplete outcome data addressed;
- Selective reporting.

Publications were grouped into the following categories [28]: low risk of bias (possible bias not seriously affecting results) if all criteria were met, high risk of bias (possible bias seriously weakening reliability of results) if one or more criteria were not met, and unclear risk of bias when too few details were available for classification as high or low risk.

Newcastle-Ottawa scale (http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp) was applied for non-randomized studies to judge each included study on selection of studies, comparability of cohorts, and the ascertainment of either the exposure or outcome of interest [29]. Stars were awarded with highest quality studies awarded up to nine stars. Included non-randomized studies were categorized as low-quality (0 to 3 stars), moderate quality (4 to 6 stars), and high quality (7 to 9 stars).

Comparative studies were also assessed according to the grading of recommendations, assessment, development, and evaluations (GRADE) system for quality of evidence [30], whereas quality assessment of included non-comparative studies was not conducted, as these studies were assumed to be associated with high risk of bias.

Statistical analysis

Parametric data involving survival of suprastructures and implants, HSPIT, gain in alveolar ridge width and postoperative dimensional changes of the alveolar ridge are presented as mean and standard deviation (M [SD]) in the tables. The level of agreement between the two raters in selecting abstracts and studies to be read in full text were measured using Cohen's kappa coefficient (κ).

RESULTS

Study selection

Search results are outlined in Figure 1. Electronic search resulted in 1213 entries. No articles were identified through hand-searching. Of these 1213 articles, 424 were excluded due to being retrieved in more than one search. A total of 34 abstracts were reviewed and full-text analysis included 13 articles. Finally, one comparative [31], and two non-comparative studies were included [32,33]. The level of agreement between the two authors (J.V. and K.B.Ø.) in selecting abstracts and studies to be read in full text were measured at k = 0.86 and 0.96, indicating strong and almost perfect reliability of agreement.

Exclusion of studies

Reasons for excluding ten studies after full-text assessment were: an experimental study in animals (n = 1) [34], less than five patients included (n = 3) [35-37], unspecified numbers of LARA procedures (n = 1) [38], and studies could not be excluded before meticulous reading (n = 2) [39,40]. Three studies were excluded [41-43], because identical patient samples with a longer observation period were presented in two of the included studies [31,33]. However, additional information's from these excluded studies are presented in the following sections.

Characteristics of the studies included

The included studies of the present systematic review consisted of one prospective, non-randomized controlled trial [31], and two prospective non-comparative observational studies [32,33]. Partial edentulous patients in need of an implant-supported fixed restoration combined with a horizontal alveolar ridge deficiency of the maxilla and mandible were enrolled. Two studies were performed in accordance with STROBE guidelines with a detailed

description of the used power analysis and sample size calculation, in which the clinical width of the alveolar ridge was chosen as the primary outcome variable [31,32]. Age and gender distribution as well as inclusion criteria and exclusion criteria were specified in all the included studies [31-33]. In the comparative study, patients with a partially or fully impacted caries-free third molar without signs of local pathologies were allocated to LARA with an autogenous tooth block graft, whereas patients without a suitable third molar were allocated to autogenous bone block graft [31]. The preoperative width of the alveolar ridge was specified in all the included studies [31-33]. The alveolar ridge defect involved either post extraction horizontal alveolar ridge deficiencies [31,32] as well as fresh deficient extraction sockets with insufficient thickness of the buccal bone or presence of a buccal dehiscence-type defect [32]. The surgical procedure was performed under local anaesthetics by an unknown number of surgeons [31-33]. The autogenous tooth block graft was prepared differently involving crown decapitation and longitudinal splitting of the root, before the pulp and cementum layer was removed to expose the underlying dentin [31,32], or the tooth was split along the root canal, followed by removal of the pulp, enamel, and part of the cementum, before the tooth block graft was immersed in 0.5% iodophor for 30 minutes [33]. The autogenous tooth block graft was covered by coral hydroxyapatite artificial bone power (Bio-Osteon bone graft - Beijing YHJ Science and Trade Co., Ltd; Beijing, China) and sealed by a resorbable barrier membrane (Heal mouth rehabilitation membrane - Yantai Zhenghai Bio-Tech Co., Ltd; Yantai, Shandong, China) [33] or no barrier membrane or additional grafting material was applied [31,32]. In the comparative study, the autogenous bone block graft was harvested from the ascending mandibular ramus and no barrier membrane or additional grafting material was used to cover the fixed autogenous bone block graft [31]. A single preoperative prescription of antibiotic was used in the comparative study and one of the non-comparative studies [31,32], while preoperative and postoperative antibiotics were prescribed for three days in the other non-comparative study [33]. Implants were inserted after 26 weeks or six months [31-33]. Straumann® Bone Level, Tapered SLActive implants (Institut Straumann AG; Basal, Switzerland) were used in two studies [31,32], while the used implant system was not specified in one study [33]. The implant stability was measure using Osstell™ ISQ device (Integration Diagnostics AB; Göteborg, Sweden) in one study [33]. The prosthetic solution included cemented single metal-ceramic crowns and bridges [31,32] or was not specified [33]. HSPIT was assessed by plaque index score, bleeding on probing, probing depth, mucosal recession, and clinical attachment level [31,32] according to Silness-Löe index [44]. Gain in alveolar ridge width and postoperative dimensional changes were measured by clinical linear measurements using a calliper [31] or radiographic linear measurement on cone beam computed tomography scan [33]. Postoperative pain response was assessed by a numerical rating scale from zero to ten (0 = no pain; 1 to 3 = mild pain; 4 to 6 = moderate pain, 7 to 10 = severe pain) [33]. All measurements were performed by a calibrated investigator in the comparative study [31], while none of the included non-comparative studies provided information about examiner, training, or calibration [32,33]. Although, it was emphasized that each sample was measured three times by one examiner in one of the non-comparative studies [33]. Numbers of dropouts including plausible explanation were reported in two studies [31,32].

Data synthesis

Meta-analyses were to be conducted only if there were studies of similar comparison, reporting identical outcome measures. However, the included studies in the present systematic review revealed considerable heterogeneity. A well-defined meta-analysis was therefore not applicable.

Methodological quality

Quality of the included comparative study is summarized in Table 2. The included comparative study was considered as high quality according to Newcastle-Ottawa scale but rated as low grade due to lack of randomized allocation sequence, blinding, allocation concealment and large losses to follow-up [31].

Table 2. Newcastle-Ottawa scale for assessing quality of non-randomized studies categorized as low-quality (0 to 3 stars), moderate quality (4 to 6 stars), and high quality (7 to 9 stars)

Study	Year of publication	Selection (maximum 4 stars)	Comparability (maximum 2 stars)	Outcome (maximum 3 stars)	Total score/quality
Schwarz et al. [31]	2019	★ ★ ★ ★	★ ★	★ ★ ★	9 stars/high quality

Outcome measures

Results of LARA with an autogenous bone block graft compared with autogenous bone block graft are presented below and outlined in Table 3, followed by results of the non-comparative studies in Table 4. All reported numerical values are presented as mean values with standard deviation. For each outcome measure, a short summary is finally provided including concluding remarks. Survival of suprastructures was not reported in any of the included studies and therefore not described in the following section or outlined in Table 3 and Table 4.

Survival of implants
Comparative studies

Survival of implants following LARA with an autogenous tooth block graft compared with autogenous bone block graft from the ascending mandibular ramus were 100% for both treatment modalities, after 26 weeks of functional implant loading [31]. However, seven patients were lost to follow-up, so the assessment of implant survival included 13 implants following LARA with an autogenous tooth block graft and ten implants following LARA with autogenous bone block graft [31].

Non-comparative studies

Survival of implants following LARA with an autogenous tooth block were 100%, after 26 weeks of functional implant loading [32].

Summary

High short-term implant survival was revealed in comparative and non-comparative studies following LARA with autogenous tooth block graft.

Implant stability quotient
Non-comparative studies

The implant stability quotient was 78.3 (6.6) at second-stage surgery following LARA with an autogenous tooth block graft [33].

Summary

The implant stability quotient was high following LARA with an autogenous bone block graft as demonstrated in a non-comparative study.

Health status of the peri-implant tissue
Comparative studies

The plaque index score, bleeding on probing, probing depth, mucosal recession, and clinical attachment level were 0.4 (0.5), 21.8 (29.1)%, 2.5 (1) mm, 0 (0), and 2.5 (1) mm following LARA with an autogenous tooth block graft, after 26 weeks of functional implant loading [31]. Corresponding measurements were 0.3 (0.4), 15 (31.8)%, 2.1 (0.6) mm, 0 (0) and 2.1 (0.6) mm following LARA with an autogenous bone block graft. There were no significant differences in bleeding on probing (P = 0.308), probing depth (P = 0.152), and clinical attachment level (P = 0.152) between the two treatment modalities, after 26 weeks of functional implant loading [31]. However, the incidence of peri-implant mucositis was higher following LARA with an autogenous tooth block graft (46.2%) compared with autogenous bone block graft (20%), after 26 weeks of functional implant loading [31].

Non-comparative studies

The plaque index score, bleeding on probing, probing depth, mucosal recession, and clinical attachment level were 0.5 (0.6), 46.2 (38)%, 2.8 (0.4) mm, 0 (0), and 2.8 (0.4) mm following LARA with an autogenous tooth block graft, after 26 weeks of functional implant loading [32]. The incidence of peri-implant mucositis following LARA with an autogenous tooth block graft was 76.9%, after 26 weeks of functional implant loading [32].

Summary

Comparable HSPIT was reported following LARA with the two treatment modalities, after 26 weeks of functional implant loading. However, a higher frequency of short-term peri-implant mucositis was observed following LARA with an autogenous tooth block graft.

Gain in alveolar ridge width
Comparative studies

The clinical alveolar ridge width was 10.2 (1.7) mm immediately following LARA with an autogenous tooth block graft and 10.1 (1.9) mm, after 26 weeks of functional implant loading [31]. Corresponding measurements were 10.2 (1.5) mm and 9.2 (2.1) mm following LARA with autogenous bone block graft. The gain in clinical alveolar width was 5.5 (1.9) mm with an autogenous tooth block graft compared with 3.9 (1.4) mm following LARA with autogenous bone

Table 3. Lateral alveolar ridge augmentation with an autogenous tooth block graft compared with autogenous bone block graft

Study	Outcome measures															
	NOP	Grafting material no.	GT (mm)	GH (weeks)	NOI	OP (weeks)	IS (%)	HSPIT			ARW			GARW	GR	
								PIS	BOP (%)	CAL (mm)	BA (mm)	IAA (mm)	IP (mm)	IP (mm)	IP (mm)	
			Mean (SD)					Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Schwarz et al. [31]	30	Third molar: 15	5.7 (1.8)*	26	15	26	100	0.4 (0.5)	21.8 (29.1)[a]	2.5 (1)[b]	4.5 (1.5)**	10.2 (1.7)***	10.1 (1.9)****	5.5 (1.9)*****	0.1 (1)******	ES: 1
		Mandible ramus: 15	5 (1.8)		15			0.3 (0.4)	15 (31.8)	2.1 (0.6)	5.3 (1.3)	10.2 (1.5)	9.2 (2.1)	3.9 (1.4)	1 (1.2)	ES: 1 SA: 1

*P = 0.22; **P = 0.164; ***P = 0.955; ****P = 0.241; *****P = 0.029; ******P = 0.014, un-paired t-test.
[a]P = 0.308, un-paired t-test.
[b]P = 0.152, un-paired t-test.
ARW = alveolar ridge width; BA = before augmentation; BOP = bleeding on probing; BTC = biological and technical complications; CAL = clinical attachment level; GH = graft healing time; GR = graft resorption; GT = graft thickness; HSPIT = health status of the peri-implant tissue; IAA = immediately after augmentation; IP = implant placement; IS = implant survival; NOP = number of patients; NOI = number of implants; OP = observation period after functional implant loading; PIS = plaque index score; SA = secondary augmentation procedure; SE = exposure of screw head; SD = standard deviation.

Table 4. Non-comparative studies assessing lateral alveolar ridge augmentation with autogenous tooth block graft

Study	Outcome measures																	
	NOP	Bone defect	Grafting material no.	GT (mm)	GH (weeks)	NOI	OP (weeks)	ISQ	IS (%)	HSPIT		ARW			GARW	GR	PROM	BCT
										BOP (%)	CAL (%)	BA (mm)	IAA (mm)	IP (mm)	IP (mm)	IP (mm)		
				Mean (SD)				Mean (SD)		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)		
Parvini et al. [32]	15	Deficient extraction socket	Autogenous tooth root: 14	5.1 (1.8)	26	14	26	NR	100	46.2 (38)	2.8 (0.4)	6 (4)		12.3 (3.2)	10.9 (1.5)	4.9 (2.3)	1.4 (1.5)	NR	FTB: 1
Wang et al. [33]	19	Alveolar ridge deficiency	Autogenous tooth root: 36	NR	26	28	NR	78.3 (6.6)	NR	NR		W1:	2.2 (0.6)	5.2 (0.9)	4.7 (0.7)	2.5 (0.7)	0.5 (0.5)	Pain (%)	None
												W2:	3.3 (0.9)	7.9 (1.7)	7.4 (1.6)	4.1 (1.4)	0.5 (0.4)	No: 0; mild: 15.8; moderate: 57.9; severe: 26.3	
												W3:	4.4 (1.5)	9.4 (2.3)	9 (2.4)	4.6 (2.1)	0.5 (0.4)		

ARW = alveolar ridge width; FTB = fracture of the tooth block graft; GARW = gain in alveolar ridge width; GH = graft healing; HSPIT = health status of the peri-implant tissue; IAA = immediately after augmentation; IP = implant placement; IS = implant survival; ISQ = implant stability quotient; NR = not reported; OP = observation period after functional implant loading; PROM = patient-reported outcome measures; SD = standard deviation, W1 = 0 mm from the alveolar crest; W2 = 3 mm from the alveolar crest; W3 = 6 mm from the alveolar crest.

block graft, after 26 weeks of functional implant loading, respectively. The difference was significant (P = 0.014) [31].

Non-comparative studies

The immediate radiographic alveolar ridge width following LARA with an autogenous tooth block graft was 5.2 (0.1) mm, 7.8 (1.7) mm and 9.4 (8.7) mm, measured at 0 mm, 3 mm, and 6 mm from the alveolar crest, respectively [33]. Corresponding measurements were 4.7 (0.7) mm, 7.4 (1.6) mm, and 9 (2.4) mm, after six months. Thus, the absolute gain in alveolar ridge width following LARA with an autogenous tooth block graft were 2.5 (0.7) mm, 4.1 (1.4) mm, and 4.6 (2.1) mm, measured at 0 mm, 3 mm, and 6 mm from the alveolar crest, after six months [33].

Summary

The final gain in alveolar ridge width was significantly higher following LARA with autogenous tooth block graft compared with autogenous bone block graft, after 26 weeks of functional implant loading. The improved gain in alveolar ridge width seems to be associated with diminished postoperative dimensional changes of the autogenous tooth block graft.

Postoperative dimensional changes of the alveolar ridge width
Comparative studies

The clinical alveolar ridge width was decreased by 0.1 (1) mm following LARA with an autogenous tooth block graft and 1 (1.2) mm with autogenous bone block graft, after 26 weeks of functional implant loading [31]. The difference was significant (P = 0.029) [31].

Non-comparative studies

The radiographic alveolar ridge width was decreased by 0.5 (0.5) mm, 0.5 (0.4) mm and 0.5 (0.4) mm measured at 0 mm, 3 mm, and 6 mm from the alveolar crest after six months, respectively [33].

Summary

LARA with an autogenous tooth block graft seems to be associated with minimal postoperative dimensional changes of the alveolar ridge width compared with autogenous bone block graft as evaluated by two-dimensional clinical and radiographic measurements.

Patient-reported outcome measures
Non-comparative studies

Numerical rating scale revealed no pain in 0%, mild pain in 15.8%, moderate pain in 57.9% and severe pain in 26.3% following LARA with an autogenous tooth block graft, after one week [33].

Summary

LARA with an autogenous tooth block graft seems to be associated with moderate to severe pain as evaluated by numerical rating scale in a non-comparative study.

Biologic and technical complications
Comparative studies

Healing was uneventful following LARA with an autogenous tooth block graft or autogenous bone block graft without infection, wound dehiscence, graft exposure, or other biologic and technical complications [31]. However, a secondary augmentation procedure of a dehiscence-type defect was necessary at implant placement following LARA with autogenous bone block graft. Moreover, exposure of the screw head without infection was observed in two patients following LARA with an autogenous tooth block graft or autogenous bone block graft, respectively [31].

Non-comparative studies

Healing was uneventful without biologic or technical complications following LARA with an autogenous tooth block [32,33]. However, one patient was excluded from the study since the autogenous tooth block graft fractured during the predrilling procedure [32].

Summary

Frequency of short-term biologic and technical complications following LARA with an autogenous tooth block graft is low and seems to be comparable with the use of autogenous bone block graft.

DISCUSSION

The objective of the present systematic review was to evaluate the current knowledge of implant treatment outcome following LARA with an autogenous tooth block graft compared with autogenous bone block

graft prior to implant placement. A prospective, non-randomized controlled clinical trial characterized by high quality and low grade [31], and two prospective non-comparative observational studies [32,33] fulfilled the inclusion criteria. Comparable implant survival rate, HSPIT, gain in alveolar ridge width and frequency of complications indicate that an autogenous tooth block graft can serve as an alternative grafting material for reconstruction of horizontal alveolar ridge deficiency prior to implant placement based on short-term studies. However, absence of well-designed randomized controlled trials related to the focus question of the present systematic review posed serious restrictions to review the literature in a quantitative systematic manner. Moreover, considerable heterogeneity and methodological confounding factors among the included comparative and non-comparative studies prevented a quantitative analysis and meta-analysis. Consequently, the conclusions provided from the results of the present systematic review should be interpreted with pronounced caution since it mainly rephrases the results of the included non-randomised prospective study with low grade. Further well-designed long-term randomized controlled trials are therefore sincerely needed before definite clinical recommendations can be provided according to the focus question of the present systematic review.

Survival of suprastructures and implants are often considered as the most important success criteria for assessment of long-term implant treatment outcomes [45]. However, survival of suprastructure was not assessed in the included studies of the present systematic review and no implant failures were reported in neither the comparative nor non-comparative studies, after 26 weeks of functional implant loading [30-32]. Consequently, long-term randomized controlled trials assessing survival of suprastructures and implants following LARA with an autogenous tooth block graft compared with autogenous bone block graft are needed before one treatment modality may be considered superior to another.

The implant stability quotient indicates the level of mechanical stability and osseointegration of the inserted implant. The scale ranges from 1 to 100, with higher values indicating greater implant stability. The average implant stability quotient after osseointegration is generally 70 and the acceptable implant stability quotient range lies between 55 and 85 [46]. However, the implant stability quotient is influenced by various clinical and biological factors including bone quality and quantity, healing time, implant location, implant design and the used measuring devices [47,48]. The implant stability quotient should therefore be considered as a supplementary instrument to the clinical and radiographic examination [49]. Previous studies have demonstrated acceptable implant stability quotient following LARA with an autogenous bone block graft [50,51]. In the present systematic review, the implant stability quotient was solely assessed in one non-comparative study revealing high values at second-stage surgery following LARA with an autogenous tooth block graft [33]. Consequently, LARA with an autogenous tooth block graft prior to implant placement seems to facilitate sufficient mechanical stability and osseointegration of the inserted implants. However, further randomized controlled trials assessing the implant stability quotient at different time points are needed to determine if there is an increase or decrease in implant stability quotient following LARA with an autogenous tooth block graft.

The HSPIT is frequently used for defining a successful implant treatment outcome [50,51]. A clinical healthy peri-implant tissue is characterized by absence of erythema, bleeding on probing, swelling, and suppuration [52]. In the present systematic review, no significant differences were observed in plaque index score, bleeding on probing, probing depth, mucosal recession, and clinical attachment level following LARA with an autogenous tooth block graft compared with an autogenous bone block graft [31]. However, clinical measurement revealed a high frequency of peri-implant mucositis following LARA with an autogenous tooth block graft, after 26 weeks of functional implant loading [31,32]. A recent published consensus report recommended that clinical examination of the HSPIT should be supplement with a radiographic examination to assess changes in the peri-implant marginal bone level [52]. However, none of the included studies of the present systematic review evaluated the HSPIT by radiographic measurements [31-33]. Consequently, long-term clinical and radiographic measurements of the HSPIT should be included in future randomized controlled trials assessing LARA with an autogenous tooth block graft.

LARA prior to placement of implants is necessary when the horizontal dimension of the alveolar ridge prevent placement of implants in an optimal prosthetically facial-oral position. Previous systematic reviews have reported a gain in alveolar ridge width of more than 4 mm following LARA with an autogenous bone block graft [3,6]. The comparative study of the present systematic review revealed no significant differences in the thickness of the grafting

material or the obtained width of the alveolar ridge immediately following LARA with the two treatment modalities [31]. However, the gain in alveolar ridge width at implant placement was significantly larger with an autogenous tooth block graft compared with autogenous bone block graft due to diminished postoperative dimensional changes of the autogenous tooth block graft [31]. The comparative study of the present systematic review used two-dimensional linear clinical measurements for assessment of gain in alveolar ridge width as well as postoperative dimensional changes, which indeed incorporates measurements error. Two-dimensional radiographic linear measurements at different landmarks were used in one of the non-comparative studies [33]. However, a block graft is an inhomogeneous and three-dimensional anisotropic structure. Three-dimensional radiographic evaluation methods are therefore mandatory for accurate assessment of gain in alveolar ridge width and postoperative dimensional changes. Thus, further long-term randomized controlled trials should include three-dimensional evaluation methods for accurate assessment of gain in alveolar ridge width and postoperative dimensional changes following LARA with an autogenous tooth block graft.

PROM are important measurements to assess whether health care services or a surgical intervention improve patients' health status or oral health-related quality of life, including symptoms and functionality as well as physical, mental and social health. Surgical removal of teeth or harvesting of an autogenous bone block graft is associated with risk of donor site morbidity and discomfort, which may cause impaired oral health-related quality of life [11]. However, these aspects were not addressed in any of the included studies of the present systematic review. LARA with an autogenous tooth block graft were associated with moderate to severe pain as reported in one of the non-comparative studies, although no information's was provided whether the symptoms was related to the donor site or the recipient site [33]. Consequently, future randomized controlled trials assessing LARA with an autogenous tooth block graft should include PROM and assessment of donor site morbidity before one treatment modality may be considered superior to another.

The frequency of biologic and technical complications was low and not severe following LARA with an autogenous tooth block graft [31-33]. Fracture of the autogenous tooth block graft and exposure of the screw head without infection was reported following LARA with an autogenous tooth block graft, whereas a secondary augmentation procedure of a dehiscence-type defect was necessary at implant placement following LARA with autogenous bone block graft [31]. Consequently, LARA with an autogenous tooth block graft seems to be a safe and predictable surgical procedure with few biologic and technical complications. However, comparison of these two treatment modalities should also contain an evaluation of donor site morbidity. However, this aspect was not addressed in any of the included studies.

Systematic reviews aim to minimize bias using pre-specified formulated research questions combined with explicit reproducible methods to systematically identify, select, and critically appraise relevant research as well as collecting and synthesize data from the included studies. A systematic review combined with meta-analyses of high-quality, long-term randomized controlled trials are considered as the highest level of evidence. However, the validity of the conclusions depends on the methodological quality and heterogeneity of the included studies. Quality and risk-of-bias assessment is therefore an integral component of the data extraction process of a systematic review. In the present systematic review, quality assessment of the included comparative study was carried out using the Newcastle-Ottawa scale and GRADE. Newcastle-Ottawa scale is an eight-item star-based scoring system assessing three quality parameters (selection, comparability, and outcome), where higher scores indicate use of favourable methodological aspects [29]. The comparative study of the present systematic review was considered as a high-quality study [31].

It has previously been reported that studies with low methodological quality and inadequate allocation concealment are associated with increased benefit of the intervention [53]. Investigators, assessors and participants should therefore be unaware of group assignment, since subjective outcomes may be influenced by knowledge of assignment. The GRADE system is used to rate the certainty of evidence for a treatment efficacy from high to very low. The comparative study of the present systematic review was rated as low grade due to lack of randomized allocation sequence, blinding, allocation concealment and large losses to follow-up [31]. Consequently, the conclusions provided from the results of the present systematic review should therefore be interpreted with pronounced caution.

CONCLUSIONS

Comparable outcomes in terms of implant survival, health status of the peri-implant tissue, gain in alveolar ridge width as well as frequency of

biologic and technical complications indicate that an autogenous tooth block graft can serve as alternative grafting material for reconstruction of horizontal alveolar ridge deficiency prior to implant placement based on one comparative and two non-comparative short-term studies. However, absence of well-designed randomized controlled trials related to the focus question of the present systematic review posed serious restrictions to review the literature in a quantitative systematic manner. Moreover, considerable heterogeneity and methodological confounding factors among the included comparable and non-comparable studies prevented a quantitative analysis and meta-analysis. Hence, conclusions drawn from results of this systematic review should be interpreted with pronounced caution since it mainly rephrases the results of the included non-randomised prospective study with low grade. Further long-term well-designed randomized controlled trials involving larger patient samples, assessment of patient-reported outcome measures as well as donor site morbidity are therefore sincerely needed before definite conclusions can be provided about the beneficial use of an autogenous tooth block graft for lateral alveolar ridge augmentation compared with autogenous bone block graft from the mandible.

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Appendix 1. Search history

Database	Interface	Result	Date
PubMed	PubMed.gov	661	20.12.2021
Embase	Embase.com	310	20.12.2021
Cochrane Library	Wiley	242	20.12.2021
All		**1213**	-
After duplicate-removal with Endnote		**789**	

Appendix 2. PubMed search until the 20th of December, 2021

Search	Query	Items found
#27	(((((((("Alveolar Ridge Augmentation"[Mesh]) OR (Alveolar Ridge Augmentat*[tw])) OR (Alveolar Augmentat*[tw])) OR (lateral Augmentat*[tw])) OR (lateral ridge Augmentat*[tw])) OR (horizontal ridge Augmentat*[tw])) OR (horizontal Augmentat*[tw])) AND ((((((("Tooth"[Mesh]) OR (tooth[tw])) OR (teeth[tw])) OR (Autogenous dentin block*[tw])) OR (Autogenous dentin graft*[tw])) OR (Third molar*[tw])))) AND ((((((((((("Randomized Controlled Trial" [Publication Type]) OR "Controlled Clinical Trial" [Publication Type]) OR "Randomized Controlled Trials as Topic"[Mesh]) OR "Controlled Clinical Trials as Topic"[Mesh]) OR "Retrospective Studies"[Mesh]) OR "Prospective Studies"[Mesh]) OR (((((((("Controlled Clinical Trial"[Publication Type] OR "Controlled Clinical Trials as Topic"[Mesh])) OR (((random*[Text Word] OR controlled[Text Word] OR crossover[Text Word] OR cross-over[Text Word] OR blind*[Text Word] OR mask*[Text Word])) AND (trial[Text Word] OR trials[Text Word] OR study[Text Word] OR studies[Text Word] OR analys*[Text Word] OR analyz*[Text Word]))) OR rct[Text Word]) OR (((singl*[Text Word] OR doubl*[Text Word] OR tripl*[Text Word])) AND (blind[Text Word] OR mask[Text Word]))) OR placebo[Text Word]))) OR ((prospective[Text Word] OR retrospective[Text Word]))) OR ("Cohort Studies"[Mesh])) OR (Longitudinal[tw])) OR (follow-up[tw])) OR (followup[tw]))	661
#26	((((((((((("Randomized Controlled Trial" [Publication Type]) OR "Controlled Clinical Trial" [Publication Type]) OR "Randomized Controlled Trials as Topic"[Mesh]) OR "Controlled Clinical Trials as Topic"[Mesh]) OR "Retrospective Studies"[Mesh]) OR "Prospective Studies"[Mesh]) OR (((((((("Controlled Clinical Trial"[Publication Type] OR "Controlled Clinical Trials as Topic"[Mesh])) OR (((random*[Text Word] OR controlled[Text Word] OR crossover[Text Word] OR cross-over[Text Word] OR blind*[Text Word] OR mask*[Text Word])) AND (trial[Text Word] OR trials[Text Word] OR study[Text Word] OR studies[Text Word] OR analys*[Text Word] OR analyz*[Text Word]))) OR rct[Text Word]) OR (((singl*[Text Word] OR doubl*[Text Word] OR tripl*[Text Word])) AND (blind[Text Word] OR mask[Text Word]))) OR placebo[Text Word]))) OR ((prospective[Text Word] OR retrospective[Text Word]))) OR ("Cohort Studies"[Mesh])) OR (Longitudinal[tw])) OR (follow-up[tw])) OR (followup[tw])	4,751,067
#25	followup[tw]	1,024,905
#24	follow-up[tw]	1,454,714
#23	Longitudinal[tw]	344,326
#22	"Cohort Studies"[Mesh]	2,267,116
#21	(((((((("Randomized Controlled Trial" [Publication Type]) OR "Controlled Clinical Trial" [Publication Type]) OR "Randomized Controlled Trials as Topic"[Mesh]) OR "Controlled Clinical Trials as Topic"[Mesh]) OR "Retrospective Studies"[Mesh]) OR "Prospective Studies"[Mesh]) OR (((((((("Controlled Clinical Trial"[Publication Type] OR "Controlled Clinical Trials as Topic"[Mesh])) OR (((random*[Text Word] OR controlled[Text Word] OR crossover[Text Word] OR cross-over[Text Word] OR blind*[Text Word] OR mask*[Text Word])) AND (trial[Text Word] OR trials[Text Word] OR study[Text Word] OR studies[Text Word] OR analys*[Text Word] OR analyz*[Text Word]))) OR rct[Text Word]) OR (((singl*[Text Word] OR doubl*[Text Word] OR tripl*[Text Word])) AND (blind[Text Word] OR mask[Text Word]))) OR placebo[Text Word]))) OR ((prospective[Text Word] OR retrospective[Text Word]))	3,648,208
#20	(((((((("Alveolar Ridge Augmentation"[Mesh]) OR (Alveolar Ridge Augmentat*[tw])) OR (Alveolar Augmentat*[tw])) OR (lateral Augmentat*[tw])) OR (lateral ridge Augmentat*[tw])) OR (horizontal ridge Augmentat*[tw])) OR (horizontal Augmentat*[tw])) AND ((((((("Tooth"[Mesh]) OR (tooth[tw])) OR (teeth[tw])) OR (Autogenous dentin block*[tw])) OR (Autogenous dentin graft*[tw])) OR (Third molar*[tw]))	1,421
#19	(((((("Tooth"[Mesh]) OR (tooth[tw])) OR (teeth[tw])) OR (Autogenous dentin block*[tw])) OR (Autogenous dentin graft*[tw])) OR (Third molar*[tw])	254,791
#18	Third molar*[tw]	10,356
#17	Autogenous dentin graft*[tw]	3
#16	Autogenous dentin block*[tw]	6
#15	teeth[tw]	125,359
#14	tooth[tw]	186,25
#13	"Tooth"[Mesh]	92,143
#12	((((((("Alveolar Ridge Augmentation"[Mesh]) OR (Alveolar Ridge Augmentat*[tw])) OR (Alveolar Augmentat*[tw])) OR (lateral Augmentat*[tw])) OR (lateral ridge Augmentat*[tw])) OR (horizontal ridge Augmentat*[tw])) OR (horizontal Augmentat*[tw])	4,766
#11	horizontal Augmentat*[tw]	69
#10	horizontal ridge Augmentat*[tw]	99
#9	lateral ridge Augmentat*[tw]	85
#8	lateral Augmentat*[tw]	62
#7	Alveolar Augmentat*[tw]	68
#5	Alveolar Ridge Augmentat*[tw]	4,677
#3	"Alveolar Ridge Augmentation"[Mesh]	4,461

Appendix 3. Embase search until the 20th of December, 2021

Search	Query	Items found
#19	#9 AND #18	310
#18	#10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17	12103590
#17	longitudinal:ti,ab,kw,de OR 'follow up':ti,ab,kw,de OR followup:ti,ab,kw,de OR 'retrospective':ti,ab,kw,de OR 'prospective':ti,ab,kw,de	4443130
#16	'longitudinal study'/exp	165047
#15	'prospective study'/exp	733023
#14	'retrospective study'/de	1175335
#13	(((single OR double OR triple) NEAR/2 (blind* OR mask*)):ti,ab,kw,de) OR placebo:ti,ab,kw,de	637833
#12	(((random* OR controlled* OR crossover OR 'cross over' OR blind* OR mask*) NEAR/3 (trial* OR study OR studies OR analy*)):ti,ab,kw,de) OR rct:ti,ab,kw,de	9193945
#11	'randomized controlled trial'/exp	690297
#10	'controlled clinical trial'/exp	865747
#9	#3 AND #8	634
#8	#4 OR #5 OR #6 OR #7	282430
#7	'third molar*':ti,ab,kw	10636
#6	'autogenous dentin block*':ti,ab,kw OR 'autogenous dentin graft*':ti,ab,kw	4
#5	tooth:ti,ab,kw OR teeth:ti,ab,kw	189414
#4	'tooth'/exp	185237
#3	#1 OR #2	2089
#2	((alveolar OR lateral OR horizontal) NEAR/3 augmentat*):ti,ab,kw	1454
#1	'alveolar ridge augmentation'/exp	960

Appendix 4. Cochrane Library search until the 20th of December, 2021

Search	Query	Items found
#1	MeSH descriptor: [Alveolar Ridge Augmentation] explode all trees	392
#2	((alveolar OR lateral OR horizontal) NEAR/3 augmentation*):ti,ab,kw	533
#3	#1 or #2	533
#4	MeSH descriptor: [Tooth] explode all trees	4200
#5	(tooth or teeth or 'Autogenous dentin block*' or 'Autogenous dentin graft*' or 'Third molar*'):ti,ab,kw	25949
#6	#4 or #5	26413
#7	#3 and #6 in Trials	242