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Buccal Bone Thickness and Mid-facial Soft Tissue Recession after Various Surgical Approaches for Immediate Implant Placement: A Systematic Review and Network Meta-analysis of Controlled Trials

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Data availability statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

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Author contributions

Maurizio S. Tonetti conceived the work. Maurizio S. Tonetti, Hong-Chang Lai, Xin-Yu Wu, and Jun-Yu Shi designed the study. Xin-Yu Wu and Jun-Yu Shi performed literature search, study selection and data collection. Xin-Yu Wu and Jacopo Buti performed the data analysis. All authors contributed to the interpretation of the data, and the draft of the report approved the final version and agreed to be accountable for the work.

Running title: Surgical techniques for type 1 implant placement

Abstract

Aim: To evaluate the relative efficacy and confidence in the precision of the results of different surgical interventions for immediate implant placement in the anterior area.

Materials and methods: Electronic searches were performed in PubMed, Embase, and Cochrane CENTRAL. Randomised controlled trials comparing different surgical techniques in anterior jaws for type 1 implant placement were included. Outcome measures included implant survival (primary outcome), buccal bone thickness reduction, and mid-facial soft tissue recession. Risks of bias assessment, network meta-analysis (NMA), sensitivity analysis, and quality of evidence assessment were performed.

Results: Twenty-two studies reporting on 948 subjects and five surgical interventions were included. Fourteen early failures were reported. Compared with open-flap surgery without tissue augmentation (*F-N*) and looking at buccal bone thickness preservation, NMA showed that there was moderate confidence that flapless surgery with hard tissue augmentation (*FL-HTA*) was better than flapless surgery without tissue augmentation (*FL-N*) or open-flap surgery with hard tissue augmentation (*F-HTA*) (mean difference -0.8 mm, 95% confidence interval: -1.1 to -0.5 mm; -0.6 mm, -0.9 to -0.4 mm; and -0.5 mm, -0.7 to -0.3 mm, respectively). There was moderate confidence that flapless surgery with hard and soft tissue augmentation (*FL-HTA&STA*) could significantly prevent mid-facial soft tissue recession compared with *FL-HTA* (-0.5 mm, -0.7 to -0.3 mm) and *FL-N* (-0.6 mm, -1.2 to -0.04 mm). However, there was no significant additional benefit in buccal bone thickness with the *FL-HTA&STA* approach compared to the *FL-HTA* approach (-0.30 mm, -0.81 to 0.21 mm).

Conclusions: For immediate implant placement in the anterior areas, a *FL-HTA* approach better preserves buccal bone thickness (moderate confidence); adding *STA* improves the stability of the mid-facial soft tissue level (moderate confidence) but at the expense of buccal bone thickness (low confidence).

Keywords: Type 1 implant placement; Surgical techniques; Systematic review.

Clinical relevance

Scientific rationale for the study. Various surgical techniques are available for type 1 implant placement. There is no evidence comparing different surgical methods to guide clinical practice.

Principle findings. In the anterior area, hard tissue augmentation (HTA) could prevent a reduction of 0.16 mm buccal bone thickness in flapless surgery. A flapless surgery could avoid a decrease of 0.26 mm and 0.63 mm buccal bone thickness with and without HTA. Soft tissue augmentation could prevent 0.51 mm mid-facial soft tissue recession in flapless surgery with HTA.

Practical implications. Flapless surgery with HTA should be considered in type 1 implant placement. The benefits of STA should be further studied.

1. Introduction

Immediate (type 1) implant placement, defined as implant placement immediately after tooth extraction, has the advantages of reduced treatment time, fewer surgical procedures, and preservation of the remaining bone (Hämmerle et al., 2004). A recent mapping review focusing on surgical approaches in the aesthetic area showed that type 1 implant placement is an area of active research focus with 141 clinical studies and 4670 patients (Wu et al., 2022). The clinical application requires the presence of a well-preserved alveolus, absence of apparent infection, and specific anatomical situations that allow the achievement of primary stability of the implant. Under these conditions, clinical studies have reported reasonable survival rates for type 1 implant placement. A previous systematic review, including 46 prospective studies, found a survival rate of 97.3% to 99% after two years (Lang et al., 2012). A more recent systematic review showed that, compared with placement in a healed ridge, type 1 implant placement results in an additional 4% early failure rate (Cosyn et al., 2019). Moreover, in a previous multicentre randomised controlled trial (RCT) comparing immediate implant placement with flap elevation using two implant designs, 15% of patients did not show primary wound closure (Lang et al., 2007). In another multicentre trial, the incidence of early wound failure following type 1 placement with flap elevation was 20.8% (Tonetti et al., 2017).

Beyond implant survival and surgical complications, aesthetic outcomes have received increasing attention due to the recognised risk of inferior aesthetics following type 1 placement (Chen & Buser, 2014). On one side, research has focused on identifying prognostic indicators for a poor aesthetic outcome (namely, resorption of the buccal plate of the bone and the presence of a thin tissue phenotype). In contrast, on the other, interventions have been devised to address them (flapless placement, hard tissue augmentation, soft-tissue augmentation, and their combinations) (Wu et al., 2022). A recent systematic review including 15 RCTs reported that hard tissue augmentation (HTA) could better preserve buccal bone thickness (BBT) and mid-facial soft tissue level (Seyssens et al., 2022). Other systematic reviews have reported similar results for the benefits of HTA in the type 1 implant placement (Clementini et al., 2015; Zaki et al., 2021). Another systematic review, which included 5 RCTs and three non-randomised controlled studies, reported that soft tissue augmentation (STA) could reduce facial soft tissue recession (MSTR) (Seyssens et al., 2021). However, the primary comparisons evaluated in RCTs usually focused on one specific aspect (such as HTA or not) while not considering others (such as flap elevation).

Consequently, despite the broad scientific documentation (Wu et al., 2022), there is no research or clinical consensus on the standard approach for type 1 placement. To plan definitive trials, it is crucial to identify the components of the surgical procedure, and the results of a high-quality systematic review with network meta-analysis could provide key input.

Thus, the objective of this systematic review was to compare and rank the different surgical interventions utilised for type 1 implant placement. The PICO format research question was: in patients requiring immediate implant placement in the premolar-to-premolar area, which surgical intervention (whether to elevate flap, whether to perform HTA and/or STA) was better regarding implant survival (primary outcome), BBT reduction, and mid-facial soft tissue recession (MSTR). A standard confidence assessment of the precision of the estimates was also performed to interpret the results correctly.

2. Materials and methods

2.1 Protocol and registration

The present review was registered with PROSPERO (No. CRD42022295625) and followed the PRISMA guidelines for the network meta-analysis (Hutton et al., 2015). Ethical approval was not required for this systematic review.

2.2 Study eligibility criteria (in PICOS format)

- *Types of participants.* Patients with a hopeless tooth in anterior sites (premolar to premolar) and looking for dental implant rehabilitation.
- *Types of interventions.* Type 1 implant placement (1) with flapless or open-flap surgery; (2) with/without hard tissue augmentation (HTA) and/or soft tissue augmentation (STA).
- *Types of comparisons:* All possible comparisons across the different combinations of the above type of interventions were considered.
- *Types of outcomes.* The primary outcome was implant survival. Secondary outcomes were buccal bone thickness (BBT) reduction and mid-facial soft tissue recession (MSTR).
- *Study design*. Only randomised controlled trials (RCTs) were included.

Studies were excluded if (1) extraction sockets were characterised by complete resorption of the buccal bone wall; (2) methods of healing were compared (submerged healing, transmucosal healing, or immediate provisionalisation); or (3) materials for tissue augmentation/implant designs/methods of healing were compared.

2.3 Information sources and search strategies

An electronic search was performed in PubMed, Embase, and Cochrane CENTRAL on December 1st 2021. Key words included "type 1", "immediate", and "dental implants". No limitation was set on publication year and language. Search strategies and results are listed in **Supplementary Table 1**. A hand search was performed by screening reference lists and citing articles (in Web of Science) of included studies.

2.4 Study selection and data collection

Two review authors (XYW and JYS) conducted the study selection procedures independently and in duplicate. Firstly, the titles and abstracts of all records were screened. Then, full texts of studies were screened if further information was needed. Reasons for exclusion at this stage were recorded. The inter-reviewer reliability (kappa correlation coefficient) of the title/abstract screening and full-text screening was 0.81 and 0.79, respectively. Any disagreement was resolved by discussion among the experts (HCL and MST).

Two review authors (XYW and JYS) extracted the data independently and in duplicate using pre-designed data extraction forms. The following information was extracted: (1) bibliometric information (author, publication year, journal); (2) study general information (sources of

funding, conflict of interest, clinical setting, and country); (3) baseline conditions (patient gender and age, number of patients, implant sites); (4) information for risk of bias assessment and quality of evidence assessment; (5) surgical details (implant system, techniques for tissue augmentation (TA) procedures, grafting materials, methods of healing); (6) outcomes including implant survival, BBT reduction, MSTR, tissue remodelling outcomes, aesthetic outcomes, and patient-reported outcome measures (PROM), as well as methods and follow-up time points of measuring the primary outcomes (implant survival, BBT reduction, MSTR). Corresponding authors were contacted for missing information.

2.5 Risk of bias assessment

Two review authors (XYW and JYS) assessed the risks of bias in included studies using the Cochrane risks of bias tool 2 for RCTs (Higgins et al., 2022), independently and in duplicate. Five domains were assessed, including bias from the randomisation process, deviation from intended interventions, missing outcome data, measurement of outcomes, and selection of results. The risk of bias was assessed as high risk, low risk, or some concerns. Any disagreement was resolved through discussion with experts (HCL and MST).

2.6 Publication bias

The publication bias in the included studies would have been explored using funnel plots constructed by the ROB-MEN tool (Chiocchia et al., 2021) as part of the evidence synthesis if at least ten studies were included in each comparison.

2.7 Data Synthesis

2.7.1 Descriptive methods

Extracted data were summarised in evidence tables to detect differences in studies' characteristics and quantify the body of evidence.

2.7.2 Quantitative methods

Metainsight tool (V3.1.13) (Owen et al., 2019) was used for evidence synthesis based on the R package netmeta (Rücker et al., 2017). Frequentist models for meta-analysis and network meta-analysis were used. Network plots were used to visually display the network of direct and indirect evidence. Forest plots were created to summarise individual study results grouped by treatment comparisons, pooled effect estimates, and their associated uncertainty for all interventions compared with the reference treatment. The validity of the network was assessed following the Cochrane handbook (Chaimani et al. 2022).

- *Measures of association*

Estimates of treatment effect for direct and indirect evidence from included trials were expressed as mean differences (MD) and 95% confidence intervals (CI) for continuous data,

and risk ratio for dichotomous data.

- *Heterogeneity, inconsistency, and transitivity*

Heterogeneity (i.e., between-trials standard deviation) and inconsistency (i.e., between-trial differences in the underlying treatment effects between comparisons) were estimated for network meta-analysis models. The assumption of transitivity within the network was assessed by exploring the distribution of patient characteristics, the similarity of interventions, and study design across comparisons.

- *Pair-wise comparisons and ranking of treatments*

All pair-wise comparisons were reported alongside relative treatment effects in ranked order for all studies and presented as point estimates with corresponding 95% CI.

- *Sensitivity analyses*

The primary data analysis was conducted where data from original studies were included based on a per-protocol (PP) approach. A sensitivity analysis was then conducted using an Intention-To-Treat (ITT) approach. For BBT reduction, sensitivity analysis was performed by methods of outcome measurement (measured on CBCT scans or through probing).

2.8 Quality of evidence and confidence in the results

The GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach was used to assess the quality of a body of evidence and rate the quality of treatment effect estimates from the network meta-analysis (Brignardello-Petersen et al., 2019; Puhan et al., 2014). In this review, the confidence in the evidence regarding BBT reduction and MSTR was assessed. Five domains were considered: the overall risk of bias, directness of evidence, consistency of results, the precision of estimates, and the risk of publication bias. In the network meta-analysis, direct and indirect evidence quality was listed and rated separately. The risks of bias for the direct estimate of effect were based on head-to-head comparisons. The risk of bias of the indirect estimate were based on two or more head-to-head comparisons sharing a common comparator, among which the lower confidence rating was recorded. The higher rating was recorded when direct and indirect evidence existed for the same comparison. The quality of the body of evidence and the confidence in the results was classified into four categories: high, moderate, low, and very low. These indicate that the actual effect lies close to/is likely to be close to/may be substantially different from/is substantially different from that of the estimate of the effect, respectively (Puhan et al., 2014). A “summary of finding” table was made to present the main findings in a transparent and structured format.

3. Results

3.1 Study selection

Electronic searches identified 1484, 470, and 1232 titles/abstracts in PubMed, Embase, and Cochrane CENTRAL, respectively. After the removal of duplicates, 1564 titles/abstracts were screened. Full texts of 68 potentially eligible articles were further screened, of which 49 were excluded for the reasons described in **Figure 1**. A hand search yielded three more studies. Finally, 23 articles representing 22 studies met our eligibility criteria and were included in this review (Abd-Elrahman et al., 2020; Bittner et al., 2020; Cardaropoli et al., 2015; Chen et al., 2007; Daif, 2013; Diana et al., 2018; Ferrantino et al., 2021; Frizzera et al., 2019; Girlanda et al., 2019; Grassi et al., 2019; Jacobs et al., 2020; Jiang et al., 2020; Kabi et al., 2020; Mastrangelo et al., 2018; Naji et al., 2021; Sanz et al., 2017; Slagter et al., 2015; Slagter et al., 2021; Stoupel et al., 2016; van Nimwegen et al., 2018; Yoshino et al., 2014; Yuenyongorarn et al., 2020; Zuiderveld et al., 2021).

3.2 Study characteristics

Of the 22 studies, 4 had three arms, and 18 had two. In 2 studies, three arms were included (Grassi et al., 2019; Naji et al., 2021), while in 2 studies, only 2 of 3 arms were included (Chen et al., 2007; Frizzera et al., 2019). A total of 5 surgical approaches were included: (1) flap elevation with no tissue augmentation (TA) (*group F-N*); (2) flap elevation with hard tissue augmentation (HTA) (*group F-HTA*); (3) flapless surgery with no TA (*group FL-N*); (4) flapless surgery with HTA (*group FL-HTA*); and (5) flapless surgery with HTA and soft tissue augmentation (STA) (*group FL-HTA&STA*). Approaches for HTA included gap filling, over-contour augmentation, and socket shield techniques. For STA, autogenous connective tissue grafting was used in all studies. Study characteristics, surgical interventions, and primary outcome measures are listed in **Table 1**. Trial information, clinical settings, and surgical details are listed in **Supplementary Table 2**.

3.3 Risk of bias assessment

The risk of bias assessment is listed in **Supplementary Table 3** and graphically presented in **Supplementary Figures 1 and 2**. Briefly, three studies were assessed as being at low risk of bias. Six studies were evaluated as having concerns about missing trial registration information to judge selective reporting. Studies assessed as being at high risk of bias were mainly due to missing information for trial registration and allocation concealment.

3.4 Data synthesis

3.4.1 Implant survival

A total of 22 studies reporting 948 patients (with an ITT protocol) and five interventions were included in the descriptive analysis of implant failure. Eight studies reported 14 implant

failures (2 in *group F-N*, 4 in *group F-HTA*, 5 in *group FL-HTA*, and 3 in *group FL-HTA&STA*). All implant failures were early failures. Summary results were reported descriptively due to the very few failure events per study across the entire dataset. Details and descriptions of implant failure are listed in **Supplementary Table 4**.

3.4.2 Buccal bone thickness (BBT) reduction

Six studies reporting five interventions reported BBT reduction, including 301 patients/implants with an ITT protocol and 293 patients/implants using a PP protocol. A network of eligible comparisons for BBT reduction is presented in **Figure 2a.** The baseline for measurement of BBT reduction was immediately after implant placement or pre-operation. The follow-up length ranged from 4 months after implant placement to one year after final restoration. For BBT reduction, a positive sign indicated a decrease of BBT, while a negative sign indicated a gain of BBT.

With a per protocol (PP) approach, in network meta-analysis, compared with *group F-N*, BBT reductions in *group F-HTA* (MD -0.53 mm, 95% CI: -0.74 to -0.31 mm), *group FL-N* (MD -0.63 mm, 95% CI: -0.86 to -0.39 mm), and *group FL-HTA* (MD -0.79 mm, 95% CI: -1.06 to -0.51 mm) were significantly smaller (**Figure 3a**). *Group FL-HTA* was ranked as the most beneficial for the preservation of BBT, showing significant less BBT reduction compared with *group FL-N* (MD -0.16 mm, 95% CI: -0.31 to -0.01 mm) and *group F-HTA* (MD -0.26 mm, 95% CI: -0.47 to -0.05 mm) (**Figure 4a**). Three comparisons had direct and indirect evidence (*group F-HTA* vs *group F-N*, g*roup FL-N* vs *group F-HTA*, *group FL-N* vs *group F-N*), and no significant inconsistency occurred. The between-trial standard deviation was 0.07 mm.

Sensitivity analysis was performed by excluding two studies (Chen et al., 2007; Sanz et al., 2017), in which the BBT was measured using a periodontal probe during surgery. Results of the network meta-analysis indicated that compared with *group F-N*, *group FL-N* (MD -0.52 mm, 95% CI: -1.02 to -0.01 mm) and *group F-HTA* (MD -0.59 mm, 95% CI: -1.07 to -0.10 mm) showed significant less BBT reduction (**Supplementary Figure 3**). Results were similar when using an intention-to-treat (ITT) analysis and sensitivity analysis (**Supplementary Figure 4**).

3.4.3 Mid-facial soft tissue recession (MSTR)

Eight studies reporting four interventions evaluated MSTR, including 300 patients/implants with an ITT protocol and 278 patients/implants with a PP protocol. A network of eligible comparisons for MSTR is presented in **Figure 2b**. The baseline for measurement of MSTR was pre-operation. The follow-up length ranged from 9.7 months after implant placement to one year after final restoration. For MSTR, a positive sign indicated an apical shift of mid-facial soft tissue level, while a negative sign indicated a coronal change of mid-facial soft tissue level.

With a PP approach, in the network meta-analysis and compared with *group F-N*, MSTR for group *FL-HTA&STA* was significantly less (MD -0.81 mm, 95% CI: -1.45 to -0.17 mm) (**Figure 3b**).

Group FL-HTA&STA was ranked as the most beneficial to the preservation of mid-facial soft tissue levels, showing significant less MSTR compared with *group FL-HTA* (MD -0.51 mm, 95% CI: -0.71 to -0.30 mm), *group FL-N* (MD -0.61 mm, 95% CI: -1.18 to -0.04 mm), and *group F-N* (**Figure 4b**). No significant difference was found between *group FL-HTA*, *group FL-N*, and *group F-N*. The between-study standard deviation was 0.05 mm. Results were similar when using a PP or ITT protocol (**Supplementary Figure 5**).

3.4.4 Other outcome measures

Tissue remodelling, aesthetic outcomes, and patient-reported outcome measures are listed in **Supplementary Table 5**. Briefly, buccal bone and ridge resorption after implant placement was observed in the studies. Aesthetic outcomes, including pink aesthetic score and implant crown aesthetic index, did not significantly differ among different surgical approaches. Overall, patients were satisfied with type 1 implant placement.

3.5 Publication bias

No publication bias could be estimated as all comparisons had fewer than ten studies.

3.6 Quality of evidence

The quality of evidence and confidence in the results are presented in **Table 2**. Looking at BBT reduction, the quality of evidence was moderate for the comparisons between *group F-HTA* vs *group F-N*, *group FL-N* vs *group F-N*, and *group FL-HTA* vs *group F-N.* Still, it was low for the comparison between *group FL-HTA&STA* vs *group F-N*. Looking at MSTR, the quality of evidence was moderate for the comparison between *group FL-HTA&STA* vs *group F-N. At the same time,* it was low for the comparisons between *group FL-N* vs *group F-N* and *group FL-HTA* vs *group F-N*. The main reason for downgrading was the high risk of bias in the included studies and imprecision.

4. Discussion

The results of this systematic review with network meta-analysis indicate moderate confidence that the best candidate approach to optimize buccal bone thickness after immediate implant placement consists of a flapless approach combined with hard tissue augmentation (HTA). There is moderate confidence that adding a soft tissue graft better preserves the buccal soft tissue position. These findings, which identified the best candidate approach for research, are essential for defining the standard intervention for immediate implant placement for future multicentre trials. These observations corroborate clinical bias/expertise that considers flapless placement with HTA essential components of immediate implant procedures. It is, however, important to fully understand the confidence level of these results' precision. Firstly, there is a large discrepancy between the body of evidence documenting immediate implant placement identified in the mapping review (Wu et al., 2022) that included 141 studies and 4670 patients and the 22 RCTs with 948 subjects included in this network meta-analysis. This raises questions about the external applicability of the observed results. Second, among the 22 included RCTs, only six RCTs reported buccal bone thickness (BBT) reduction, and eight RCTs reported mid-facial soft tissue recession (MSTR). According to a recent systematic review, for studies on type 1 implant placement, implant survival is the most commonly reported outcome (82.7%). In comparison, hard and soft tissue changes were less frequently reported (in 27.2% and 40.7%, of trials, respectively) (Shi et al., 2022). The measuring and reporting of outcomes in the original studies need standardisation. Third, the effect was assessed using two surrogate outcomes: BBT reduction and mean MSTR. Their validity in capturing aesthetic results and stability has not been thoroughly evaluated. Forth, the effect size is notable, particularly for BBT reduction: -0.8 mm (95% CI -0.5 to -1.1 mm; MSTR: -0.3 mm, 95% CI -0.3 to -0.9 mm). This effect size needs to be assessed considering the small between-trial standard deviation (0.07 mm for BBT reduction and 0.05 for MSTR) and the moderate confidence in the results (for BBT and MSTR) due to the risk of bias analysis of these studies. The confidence assessment was performed using a standard instrument (GRADE for network meta-analyses) that reflects confidence in the precision of the estimates. Fifth, differences in the length of observation between the trials may add imprecision to the estimates. Lastly, the key results of the network meta-analysis are partially based on indirect comparisons. In addition, an open-flap approach without tissue augmentation, which is the traditional surgical approach that was set as the control group in most RCTs, was chosen as the common comparator in the network. Flapless surgery and tissue augmentation techniques were developed more recently based on the open-flap approach (Wu et al., 2022). A flapless approach with HTA is likely superior for the preservation of BBT. At the same time, adding a connective tissue graft is beneficial to preventing buccal soft tissue recession (moderate confidence) but at the expense of buccal bone thickness (low confidence). The benefits, if any,

of adding a connective tissue graft (or other soft tissue substitutes) to flapless implant placement with HTA need to be further assessed in primary research trials.

In the included studies, 14 implants failed, and all were early failures. This confirmed the previous systematic review (Lang et al., 2012) and RCT (Lang et al., 2007) reporting that type 1 implant placement had a reasonable survival rate. However, one limitation of this review is that no data synthesis was performed with implant survival (primary outcome), due to the very few failure events per study across the entire dataset. It is indicated that, in future studies, implant survival should not be the only outcome. The research should focus on other aspects, such as esthetic and peri-implant health outcomes. Researchers should focus on a series of standardised core outcome measures to improve the efficiency of the research process and the transparency in the outcome reporting (Shi et al., 2022).

Regarding post-surgery complications, according to the present review, only three included studies reported few complications, contrary to a previous multicentre RCT. In the cited RCT performing type 1 implant placement with flap elevation (Tonetti et al., 2017), a composite wound failure index was calculated, including wound dehiscence, oedema, and suppuration six weeks after surgery. The RCT reported that wound failure occurred at 26% of type 1 implant placement sites, almost five times more frequently than delayed implant placement. The RCT attributed the high frequency of type 1 implant placement-associated wound failure to the following factors. Firstly, obtaining primary closure at the palatal aspect was difficult. Secondly, the periodontal ligament plexus was obliterated after dental implant placement, resulting in limited blood supply and challenges in maintaining papilla closure during early healing. Thirdly, bone augmentation might have a potential impact on early healing. In the present study, no included studies analysed the early healing phase and no further information on early wound healing could be provided. Future studies should focus on minimising surgical trauma and optimising wound healing outcomes.

Type 1 implant placement without HTA could not preserve the buccal bone dimension (Araújo et al., 2005). Type 1 implant placement with flap elevation without tissue augmentation (TA) was reported to have up to 56% resorption of the buccal bone dimension (Botticelli et al., 2004). Subsequent RCTs have reported the benefits of HTA on the stability of buccal bone dimension after type 1 implant placement (Chen et al., 2007; Sanz et al., 2017), and HTA was commonly required for type 1 implant placement (Tonetti et al., 2017). Thus, HTA was recommended as a necessary procedure for the type 1 implant placement (Tonetti et al., 2019). The results of the present study indicated, with moderate confidence, that HTA could prevent 0.16 mm BBT reduction for a flapless approach and 0.53 mm BBT reduction for an open-flap approach. Previous systematic reviews have reported that HTA could prevent a BBT reduction of 0.52 mm (Zaki et al., 2021) and 0.59 mm (Seyssens et al., 2022), which were similar to the

present findings. However, materials for HTA among studies are different, including xenograft, alloplastic materials, and blood derivatives, which might introduce risks of bias to data synthesis. Because of limited evidence, the present review did not analyze the different materials separately. Future primary studies could further explore the influence of different grafting materials for tissue augmentation for immediate implant placement.

However, the current evidence could not suggest any benefit of HTA to preserving mid-facial soft tissue levels, which was contradictory to the previous studies (Seyssens et al., 2022). It might be explained that in the current study, flapless/open-flap surgeries and surgeries with/without HTA were analysed separately. Thus, the number of studies and participants in each comparison was limited, which might cause heterogeneity (between-trial standard deviation, 0.07 mm for BBT reduction, 0.05 mm for MSTR). In addition, this study showed that HTA could not preserve mid-facial soft tissue levels when combined with flapless surgery.

The different HTA techniques, such as gap filling, over-contour augmentation, or socket shield technique, were not further analyzed in this study. Another systematic review reported that gap filling showed 0.58 mm BBT reduction while over-contour augmentation showed 0.80 mm BBT reduction, without significant difference (Mao et al., 2021). However, the choice of HTA techniques was mainly based on the presence of an initial buccal bone defect, which was different among studies. In addition, it was challenging to distinguish gap filling and over-contour augmentation if the original studies did not make detailed descriptions. Thus, comparing the different HTA techniques in the current study might introduce heterogeneity. Future RCTs are needed to explore the outcomes and indications for other HTA techniques.

Aesthetics has been a significant concern following type 1 implant placement, and MSTR was an important outcome measure (Chen & Buser, 2014). According to a prospective study including 22 patients receiving type 1 implant placement, MSTR was 0.53 mm and 0.58 mm in 5- and 10-year follow-ups (Seyssens et al., 2020), which indicated an ongoing trend of MSTR. In this review, all studies used autogenous connective grafts. With a follow-up length of 1 year, moderate evidence suggested that when in combination with flapless surgery and HTA, STA could reduce a 0.5 mm MSTR. Concerning advanced MSTR (≥ 1 mm), one study reported 2/25 cases with advanced MSTR in the STA group while 8/25 patients with advanced MSTR in the no-STA group (van Nimwegen et al., 2018). A previous systematic review reported that STA could prevent 0.41 mm of MSTR and decrease the risk for advanced MSTR by 12 times (Seyssens et al., 2021). A recent consensus stated that STA simultaneously with type 1 implant placement might be recommended to reduce soft tissue recession and increase mucosa thickness (Thoma et al., 2021). However, increased patient morbidity (Thoma et al., 2016) and inferior soft tissue texture (van Nimwegen et al., 2018) have been reported when autogenous connective tissue graft was used. In addition, the results of the present study indicated that compared with *group FL-HTA*, *group FL-STA&HTA* showed slightly more BBT reduction (0.3

mm). This might be explained that when performing a connective tissue graft, the elevation of the tunnel flap might influence blood supply. Future studies should focus on optimising STA outcomes and substitute materials for STA to avoid surgical trauma from harvesting autogenous connective tissue. Furthermore, MSTR after type 1 implant placement is influenced by other factors, such as the gingival phenotype (Bittner et al., 2019), the initial buccal bone thickness (Yang et al., 2019), the abutment design (Perez et al., 2020), or the three-dimensional implant position (Seyssens et al., 2020). A prosthetically guided implant position is essential for peri-implant health and esthetic outcomes. Buccal implant position might increase the risks of mid-facial soft tissue recession (Seyssens et al., 2020). It is recommended that future studies use guided surgery to improve the outcomes and minimise the influence of implant position on esthetic results.

This study's indirect comparisons suggested that a flapless approach could better preserve BBT. This agreed with a recent systematic review that flapless and open-flap type 1 implant placement showed 0.62 mm and 0.82 mm BBT reduction, respectively (Mao et al., 2021). The advantages of a flapless approach include minimised surgical trauma, preservation of periosteum and blood supply, maintenance of the position of mucogingival conjunction, simplified operation procedures, reduced patient mobility, and higher acceptance of implant therapy from patients (Kan et al., 2018). However, according to previous animal studies, compared with an open-flap surgery, a flapless surgery could prevent BBT reduction, but the preventive effect was limited (Araújo et al., 2005; Caneva et al., 2010). Without augmentation procedures, flapless and open-flap surgeries would undergo significant ridge resorption. In the present study, compared with open-flap surgeries, flapless surgeries could prevent 0.63 mm BBT reduction when HTA was not performed and prevent 0.26 mm BBT reduction when HTA was performed. It suggested that for limiting BBT reduction, the benefit of flapless surgery was not as significant as HTA. In addition, flap elevation had no significant influence on mid-facial soft tissue level. Only one study compared flapless and open-flap type 1 implant placement without TA, reporting 0.22 mm MSTR for flapless surgeries and 0.42 mm for open-flap surgeries at 1-year follow-up, respectively (Stoupel et al., 2016). The same study reported 1/16 cases showing advanced MSTR in the flapless group, while 4/18 patients showed advanced MSTR in the open-flap group. The association between aesthetic outcomes and the increased surgical risks derived from flap elevation was unclear. The influence of flap-elevation on long-term MSTR needs further research.

The present review failed to analyse the influence of prosthetic factors because of the limitation of available RCTs. The heterogeneity derived from different forms of healing might influence the outcomes. A recent systematic review assessed the timing of restoration for the immediate implant and reported that immediate provisionalisation might contribute to mid-

facial soft tissue level stability (Pitman et al., 2022). In addition, recent RCTs reported that crown contour influenced the mid-facial soft tissue level (Siegenthaler et al., 2022). Further studies are needed to explore the influence of timing and shape of restoration on early healing and long-term outcomes for immediate implants.

5. Conclusions

In cases of extraction socket with buccal bone wall preservation in the anterior area, immediate implant placement had a good survival rate. Among different surgical interventions for immediate (type 1) implant placement, a flapless and hard tissue augmentation approach could better preserve buccal bone thickness. Adding soft tissue augmentation could better maintain the mid-facial soft tissue level. Within the limitation of the study, it could not be identified which surgical intervention is the most appropriate for clinical care. Additional research, with long-term follow-up and standardized outcome measures, is needed.

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Figure legend

Figure 1 Flow diagram of study selection

Figure 2 Network plots for (a) BBT reduction and (b) MSTR. Node size by sample size, edge width by the number of studies.

Figure 3 Forest plots for (a) BBT reduction and (b) MSTR with a PP protocol.

Figure 4 League table indicating the ranking of surgical interventions, with a PP protocol. (a) BBT reduction. A superior treatment has negative values in BBT reduction. (b) MSTR. A positive sign for MSTR means reduction of mid-facial soft tissue level, indicating an apical shift of soft tissue margin. A superior treatment has negative values in MSTR.
Surgical interventions are reported in the ranked order. Pari-wise meta-analyses (MD, 95% CI) are presented in the top half of the table. The estimates from the network met-analyses model are presented in the lower half of the table, with *group F-N* as reference. †No significant inconsistency between direct and indirect evidence.

Identification

Screening

Eligibility

Included

Records identified through database searching (n=3186):
PubMed (n=1484), EMBASE (n=470), Cochrane CENTRAL (n=1232)

Records after duplicates removed (n=1564)

Records screened on the basis of title and abstract (n=1564)

Full-text articles assessed for eligibility (n=68)

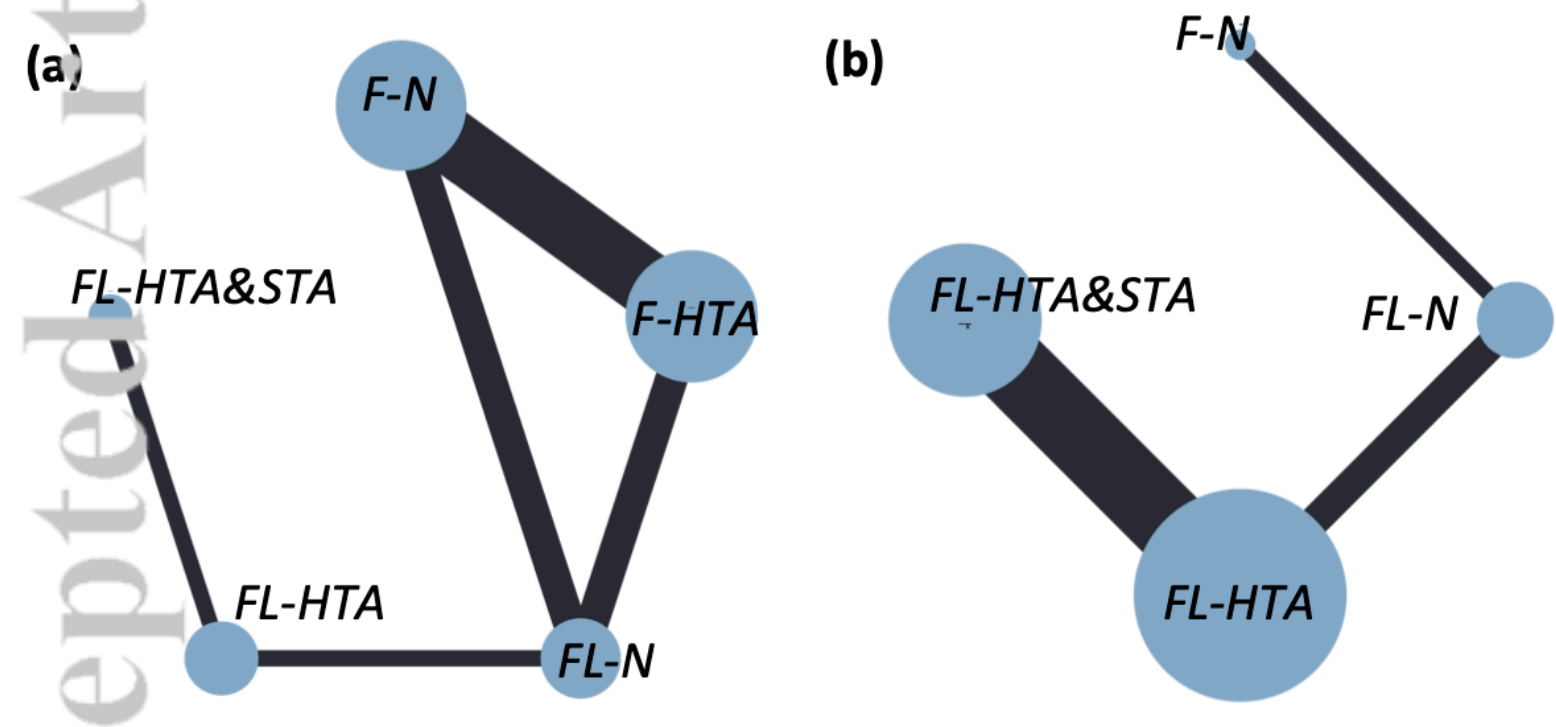
Full-text articles excluded (n=49):

- ✧ Comparisons of grafting materials/implant/restoration design/methods of healing for the same surgical intervention (n=37)
- ✧ Including posterior implants (n=12)

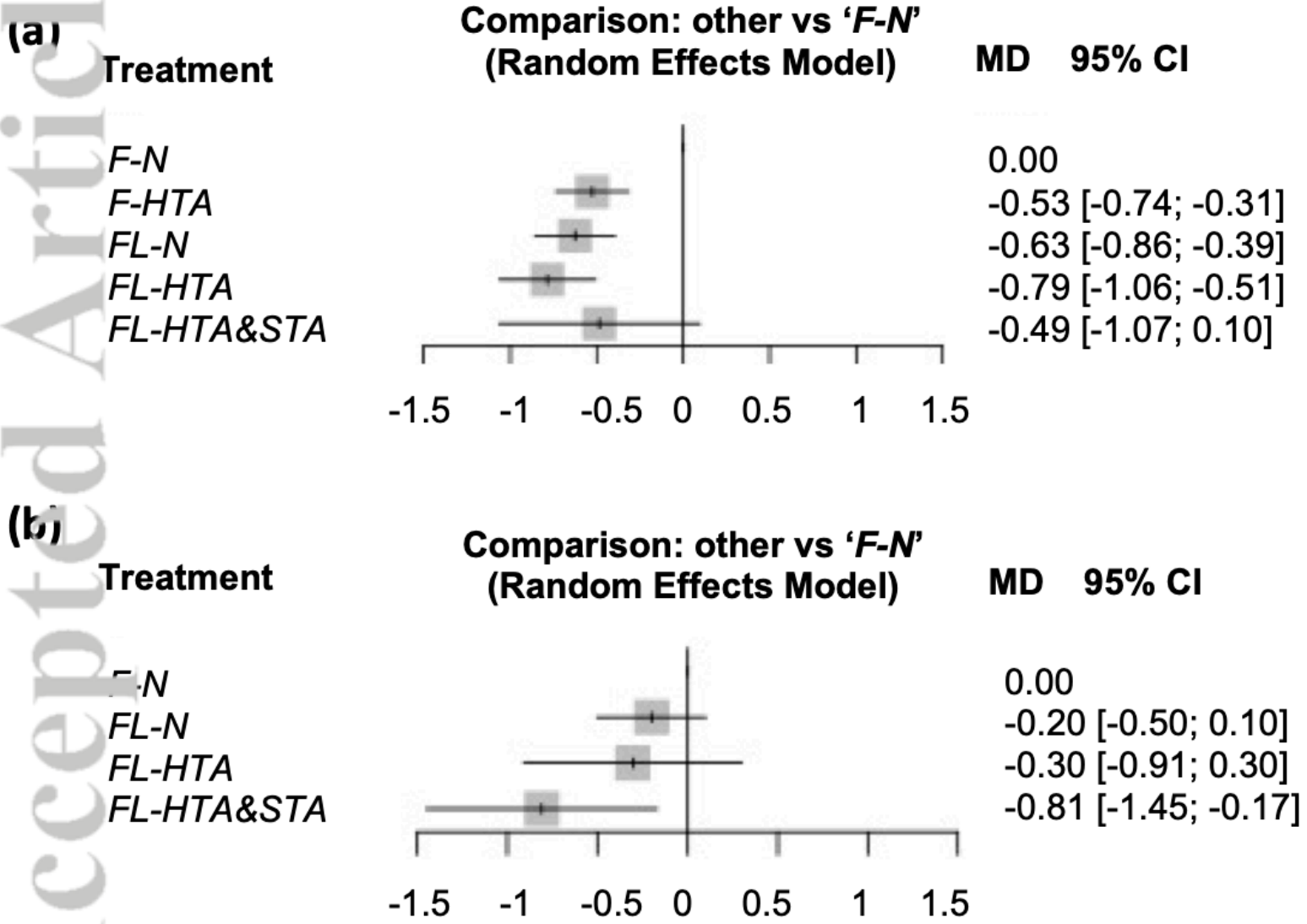
Studies included in qualitative synthesis (n=19)

Studies identified through hand search (n=3)

Studies included in quantitative synthesis (meta-analysis) (n=22)



JCPE_13771_[NM type 1] Figure 2.tiff



JCPE_13771_[NM type 1] Figure 3.tiff

(a)

FL-HTA	-0.16 (-0.31, -0.01)	-0.30 (-0.81, 0.21)	NA	NA
-0.16 (-0.31, -0.01)	**FL-N**	NA	-0.10 (-0.25, 0.05)	-0.59 (-0.87, -0.31)
-0.30 (-0.81, 0.21)	-0.14 (-0.67, 0.39)	**FL-HTA&STA**	NA	NA
-0.26 (-0.47, -0.05)	-0.10 (-0.25, 0.05)†	0.04 (-0.51, 0.59)	**F-HTA**	-0.55 (-0.76, -0.33)
-0.79 (-1.06, -0.51)	-0.63 (-0.86, -0.39)†	-0.49 (-1.07, 0.10)	-0.53 (-0.74, -0.31) †	**F-N**

(b)

FL-HTA&STA	-0.51 (-0.71, -0.30)	NA	NA
-0.51 (-0.71, -0.30)	**FL-HTA**	-0.10 (-0.63, 0.42)	NA
-0.61 (-1.18, -0.04)	-0.10 (-0.63, 0.42)	**FL-N**	-0.20 (-0.50, 0.10)
-0.81 (-1.45, -0.17)	-0.30 (-0.91, 0.30)	-0.20 (-0.50, 0.10)	**F-N**

Pare-wise comparison (MD, 95% CI) Network meta-analysis (MD, 95% CI)

JCPE_13771_[NM type 1] Figure 4.tiff

Table 1 Characteristics of included studies

Study	**Jaws, implant sites, buccal bone wall**	**Grouping information** No of patients/implants randomized (evaluated)	**Surgical interventions** Flap design/TA/methods of healing	**Main outcomes** Follow-up length, methods of measuring
Abd-Elrahman 2020	MAX&MAN, 5-5, intact	Group 1: 16 (16)/20 (20) Group 2: 18 (18)/20 (20)	Group 1: Flapless/HTA (socket shield technique)/IP Group 2: Flapless/No TA/IP	1.Implant survival, 6 months after surgery; 2.BBT, immediately to 6 months after surgery, CBCT scan
Bittner 2020	MAX, 4-4, intact	Group 1: 16 (16)/16 (16) Group 2: 16 (15)/16 (15)	Group 1: Flapless/HTA/IP or T Group 2: Flapless/No TA/IP or T	1.Implant survival, 1 year after surgery; 2.MSTR, before to 1 year after surgery, probing using stents
Cardaropoli 2014	MAX&MAN, 5-5, intact	26 (26)/26 (26) per group	Group 1: Flapless/HTA/T Group 2: Flapless/No TA/T	1.Implant survival, 1 year after surgery
Chen 2007	MAX, 5-5, buccal attachment loss<5 mm	10 (10)/10 (10) per group	Group 1: Flap/HTA/S (excluded) Group 2: Flap/HTA/S Group 3: Flap/No TA/S	1.Implant survival, 3 years after restoration 2. BBT, immediately to 6 months after surgery, measured during re-entry surgery using probe
Daif 2013	MAN, premolars, NR	14 (14)/14 (14) per group	Group 1: Flap/No TA/S Group 2: Flap/HTA/S	1.Implant survival, 6 months after restoration
Diana 2018	MAX&MAN, 5-5, intact	31 (29)/41 (39) in total	Group 1: Flap/No TA/S Group 2: Flap/HTA/S	1.Implant survival, 1 year after surgery
Ferrantino 2021	MAX&MAN, 5-5, buccal bone defect≤1 mm	Group 1: 31 (30)/31 (30) Group 2: 28 (26)/28 (26)	Group 1: Flapless/HTA&STA/IP Group 2: Flapless/HTA/IP	1.Implant survival, 1 year after surgery
Frizzera 2019	MAX, 2-2, buccal attachment loss>3 mm	8 (8)/8 (8) per group	Group 1: Flapless/HTA/IP Group 2: Flapless/HTA&STA/IP Group 3: Flapless/HTA/IP (excluded)	1.Implant survival, 1 year after surgery; 2.MSTR, before to 1 year after surgery, intra-oral photos
Girlanda 2019	MAX, 2-2, presence	11 (11)/11 (11) per group	Group 1: Flapless/HTA/T Group 2: Flapless/No TA/T	1.Implant survival, 6 months after surgery

Grassi 2019	MAX, premolars, buccal bone defect<3 mm	Group 1: 15 (15)/15 (15) Group 2: 15 (14)/15 (14) Group 3: 15 (15)/15 (15)	Group 1: Flap/HTA/S Group 2: Flap/No TA/S Group 3: Flapless/No TA/S	1.Implant survival, 6 months after surgery 2.BBT, immediately to 6 months after surgery, CBCT scan
Jacobs 2020	MAX, 4-4, intact	Group 1: 19 (19)/19 (19) Group 2: 14 (14)/14 (14)	Group 1: Flapless/HTA/T Group 2: Flapless/No TA/T	1.Implant survival, 9.7 months after surgery; 2.MSTR, before to 9.7 months after surgery, intra-oral photos
Jiang 2020	MAX, 2-2, intact	Group 1: 20 (20)/20 (20) Group 2: 20 (20)/20 (20)	Group 1: Flapless/HTA&STA/IP Group 2: Flapless/HTA/IP	1.Implant survival, 6 months after surgery
Kabi 2020	MAX&MAN, 5-5, NR	Group 1: 17 (16)/17 (16) Group 2: 16 (16)/16 (16)	Group 1: Flapless/HTA/T Group 2: Flapless/No TA/T	1.Implant survival, 9 months after surgery
Mastrangelo 2018	MAX&MAN, premolars, NR	Group 1: 54 (51)/NR (64) Group 2: 54 (51)/NR (51)	Group 1: Flap/HTA/S Group 2: Flap/No TA/S	1.Implant survival, 3 years after restoration
Naji 2021	MAX, premolars, intact	Group 1: 16 (14)/16 (14) Group 2: 16 (16)/16 (16) Group 3: 16 (15)/16 (15)	Group 1: Flap/HTA/S Group 2: Flap/No TA/S Group 3: Flapless/No TA/S	1.Implant survival, 6 months after surgery 2.BBT, immediately to 6 months after surgery, CBCT scan
Sanz 2017	MAX, 5-5, intact	Group 1: 45 (43)/45 (43) Group 2: 45 (43)/45 (43)	Group 1: Flap/HTA/T Group 2: Flap/No TA/T	1.Implant survival, 4 months after surgery 2.BBT, immediately to 4 months after surgery, measured during re-entry surgery using probe
Slagter 2021	MAX, 4-4, buccal bone defect<5 mm	Group 1: 20 (20)/20 (20) Group 2: 20 (19)/20 (19)	Group 1: Flapless/HTA/IP Group 2: Flapless/HTA&STA/S	1.Implant survival, 5 years after surgery; 2.MSTR, before to 1/5 years after surgery[†], intra-oral photos
oupel 2016	MAX, 5-5, intact	Group 1: 18 (16)/18 (16) Group 2: 21 (18)/21 (18)	Group 1: Flapless/No TA/IP Group 2: Flap/No TA/IP	1.Implant survival, 1 year after surgery; 2.MSTR, before to 1 year after surgery, casts
vanNimwegen 2018	MAX, 4-4, intact	Group 1: 30 (25)/30 (25) Group 2: 30 (25)/30 (25)	Group 1: Flapless/HTA&STA/IP Group 2: Flapless/HTA /IP	1.Implant survival, 1 year after final restoration; 2.MSTR, before to 1 year after final restoration, intra-oral photos
Yoshino 2014	MAX, 4-4, intact	10 (10)/10 (10) per group	Group 1: Flapless/HTA&STA/IP Group 2: Flapless/HTA /IP	1.Implant survival, 1 year after surgery; 2.MSTR, before to 1 year after surgery, casts
Yuenyongorarn 2020	MAX, 2-2, NR	10 (10)/10 (10) per group	Group 1: Flapless/HTA /IP Group 2: Flapless/No TA /IP	1.Implant survival, 1 year after surgery

Zuiderveld 2021	MAX, 4-4, buccal bone defect<2 mm	Group 1: 30 (28)/30 (28) Group 2: 30 (27)/30 (27)	Group 1: Flapless/HTA&STA/IP Group 2: Flapless/HTA /IP	1.Implant survival, 1 year after final restoration; 2.MSTR, before to 1 year after final restoration, intra-oral photos; 3.BBT, before to 1 year after final restoration, CBCT scan

†The number of patients/implants and MSTR recorded at 1 year after surgery was used for data synthesis. Implant sites, 5-5, region between bilateral second premolars; 4-4, region between bilateral first premolars; 2-2, incisors and lateral incisors. Abbreviations. MAX=maxilla, MAN=mandible, TA=tissue augmentation, HTA=hard tissue augmentation, STA=soft tissue augmentation, IP=immediate provisionalisation, T=transmucosal healing, S=submerged healing, MSTR=mid-facial soft tissue recession, BBT=buccal bone thickness, NR=not reported.

Table 2 Summary of findings

Which surgical intervention should be used for type 1 implant placement in esthetic area?

Patient or population: patients with hopeless single tooth in esthetic area, looking for dental implant rehabilitation
Setting: university hospital, private practice
Intervention: *F-HTA, FL-N, FL-HTA, FL-HTA&STA*
Comparison: *F-N*

Outcomes	Mean difference and 95% confidence interval, main comparator is *F-N* unless specifically mentioned				
	F-HTA	*FL-N*	*FL-HTA*	*FL-HTA&STA*	*F-N*
BBT reduction	MD **0.53 mm fewer** (0.74 fewer to 0.31 fewer) ⊕⊕⊕◯ Moderate† based on 167 participants (4 trials)	MD **0.63 mm fewer** (0.86 fewer to 0.39 fewer) ⊕⊕⊕◯ Moderate† based on 61 participants (2 trials)	MD **0.79 mm fewer** (1.06 fewer to 0.51 fewer) ⊕⊕⊕◯ Moderate† based on indirect comparison	MD **0.49 mm fewer** (1.07 fewer to 0.10 more) ⊕⊕◯◯ Low‡ based on indirect comparison	The mean BBT reduction ranged from **0.91 to 1.59** mm
MSTR	Not determined	MD **0.20 mm fewer** (0.50 fewer to 0.10 more) ⊕⊕◯◯ Low‡ based on 34 participants (1 trial)	MD **0.30 mm fewer** (0.91 fewer to 0.30 more) ⊕⊕◯◯ Low‡ based on indirect comparison	MD **0.81 mm fewer** (1.45 fewer to 0.17 fewer) ⊕⊕⊕◯ Moderate† based on indirect comparison	The mean MSTR was **0.42** mm

The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: confidence interval; **MD:** mean difference

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Footnote
† Downgrade one level: high risks of bias of studies
‡ Downgrade two levels: high risks of bias of studies and imprecision (95% confidence interval including null effect line)
F-N, flap elevation, no tissue augmentation; *F-HTA*, flap elevation, hard tissue augmentation; *FL-N*, flapless, no tissue augmentation; *FL-HTA*, flapless, hard tissue augmentation; *FL-HTA&STA*, flapless, hard and soft tissue augmentation.