Table 1. *Cont.*

Author and Year	Type of Article	Material or Subjects	Control Sample or Group	Method	Outcome Measured	Results	
Lingling Qiu et al., 2012 [38]	Nonradmized clinical experimental study	20 implants inserted with the use of a 3D surgical guide	10 implants inserted manually without any guide	Measurements on CBCT scans	Deviation from "gold standard" lines projected by specialized software	**Surgical Guided screws** The mean apical deviation was 0.28 ± 0.23 mm and 0.33 ± 0.25 mm in mesiodistal and apical directions. The mean coronal deviation was 0.15 ± 0.09 mm and 0.19 ± 0.19 mm in mesiodistal and apical direction. The angular deviations were 1.47° ± 0.56 and 2.13° ± 1.48, respectively. All the mini-implants were inserted into interradicular space.	**Manually inserted screws** The mean apical deviation was 0.81 ± 0.61 mm and 0.78 ± 0.49 mm in mesiodistal and apical directions. The mean coronal deviation was 0.48 ± 0.46 mm, and 0.94 ± 0.87 mm in mesiodistal and apical directions. The angular deviations were 7.49° ± 6.09 and 6.31° ± 3.82, respectively. All the miniimplants were inserted into interradicular space.
Möhlhenrich et al., 2019 [39]	Nonradmized clinical experimental study	20 implants inserted with the use of a 3D tooth-borne surgical guide	20 implants inserted with the use of a 3D mucosa-borne surgical guide	Measurements on cephalograms, plaster models and intraoral scans	Deviation from "gold standard" lines projected by specialized software	Statistical differences between tooth-borne and mucosa-borne guides were detected for lateral deviations: 0.88 mm ± 0.46 versus 1.65 mm ± 1.03 and sagittal angular deviations: 3.67° ± 2.25 versus 6.46° ± 5.5. All the MI were inserted into interradicular space.	
Möhlhenrich et al., 2020 [40]	Nonradmized clinical experimental study	20 implants inserted with the use of a 3D tooth-borne surgical guide	20 implants inserted with the use of 3D a mucosa-borne surgical guide	Measurements on cephalograms, CBCT, plaster models and intraoral scans	Deviation from "gold standard" lines projected by specialized software separately on cephalogram and CBCT	Significant differences between T0 and T1 were only noted in terms of lateral deviation using the tooth-borne guide (T0: 4.7 ± 2.3 mm, T1: 3.0 ± 2.3 mm;) and linear sagittal deviation using the mucosa-borne guide (T0: 3.1 ± 3.5 mm, T1: 2.3 ± 3.2 mm). All the mini-implants were inserted into palate.	
Kniha et al., 2020 [41]	Nonradmized clinical experimental study	20 implants inserted with the use of a 3D tooth-borne surgical guide	20 implants inserted with the use of a 3D mucosa-borne surgical guide	Measurements on CBCT scans	Deviation from "gold standard" lines projected by specialized software	The only statistically significantly different variable was implant axis angulation. In tooth-borne guides it was 2.81° ± 2.69. In mucosa-borne guides it was 6.22° ± 4.26. All the mini-implants were inserted into interradicular space.	

Table 1. *Cont.*

Author and Year	Type of Article	Material or Subjects	Control Sample or Group	Method	Outcome Measured	Results
Federica Altieri and Michele Cassetta, 2020 [42]	Randomized clinical trial	18 subjects with computer-aided designed skeletal RME appliance	18 subjects with classic hyrax appliance	Pain scales and shortened Oral Health Impact Profile (OHIP-14) questionnaire	Level of pain and quality of life for 14 days after insertion	The only differences were noted on the day of screw activation. Patients with a computer-guided skeletal RME appliance felt less comfortable. All the mini-implants were inserted into interradicular space.

3.2. Quality Assessment

The results of quality assessment are presented in Table 2.

Table 2. Mixed Methods Appraisal Tool (MMAT), version 2018 for quantitative randomized and nonrandomized studies.

Category of Study Designs	Methodological Quality Criteria	Suzuki and Suzuki, 2007	Rashid et al., 2021	Dasomi Kim, 2019	Mi-Ju Bae, 2013	Lingling Qiu et al., 2012	Möhlhenrich et al., 2019	Möhlhenrich et al., 2020	Kniha et al., 2020	Federica Altieri and Michele Cassetta, 2020
Screening questions	S1. Are there clear research questions?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	S2. Do the collected data allow to address the research questions?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quantitative randomized controlled trials	1.1. Is randomization appropriately performed?	N/A	Yes	Yes	N/A	N/A	N/A	N/A	N/A	Yes
	1.2. Are the groups comparable at baseline?	N/A	Yes	Yes	N/A	N/A	N/A	N/A	N/A	Yes
	1.3. Are there complete outcome data?	N/A	Yes	Yes	N/A	N/A	N/A	N/A	N/A	Yes
	1.4. Are outcome assessors blinded to the intervention provided?	N/A	Can't tell	No *	N/A	N/A	N/A	N/A	N/A	No *
	1.5 Did the participants adhere to the assigned intervention?	N/A	Yes	Yes	N/A	N/A	N/A	N/A	N/A	Yes
Quantitative nonrandomized	2.1. Are the participants representative of the target population?	Yes	N/A	N/A	Can't tell	No	Yes	Yes	Yes	N/A
	2.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	Yes	N/A	N/A	Can't tell	Yes	Yes	Yes	Yes	N/A
	2.3. Are there complete outcome data?	Yes	N/A	N/A	Yes	Yes	Yes	Yes	Yes	N/A
	2.4. Are the confounders accounted for in the design and analysis?	Yes	N/A	N/A	No *	No *	No *	No *	No *	N/A
	2.5. During the study period, is the intervention administered (or exposure occurred) as intended?	Yes	N/A	N/A	Yes	Yes	Yes	Yes	Yes	N/A

*—additionally, no error study is performed, when possible.

The overall quality of the evidence is good or average; none of the included studies were characterized by a low quality. Error study and power study were not performed for all of the studies. Most of the studies did not address the limitations that might arise from the design of the given study.

3.3. Meta-Analysis

The following meta-analysis was performed in order to compare the range of apical deviation (in mm) of miniscrews inserted using different methods. If this value was not provided, the study was excluded from a meta-analysis. Due to the large diversity of the included studies, as many as 3 comparisons were made:

(a) Accuracy of insertion of mini-implants using a 3D surgical guide to these inserted manually (no-guide). Three studies were included in the meta-analysis. The total sample size of all included studies was 220 implants.
(b) Accuracy of insertion of mini-implants using a 3D surgical guide in comparison to those inserted using a less-advanced method (manually and wire guides combined). There were four included studies in meta-analysis. The total sample size of all included studies was 285 implants.
(c) Accuracy of insertion of mini-implants using a tooth-borne 3D surgical guide to these inserted using mucosa-borne ones. Three studies were included in the meta-analysis. The total sample size of all included studies was 120 implants.

Data from all of the studies included in first and second comparison concern mini-implants inserted into the interradicular space. However, data from all of the studies included in the first and second comparison concern mini-implants inserted into the palate. The extracted data that were used to perform meta-analysis are presented in Tables 3–5.

Table 3. Differences in apical deviation to the "gold standard line" of the mini-implants inserted with the use of 3D surgical guide and the mini-implants inserted manually.

Author and Year	Deviation in the Group with the Use of Surgical Guide		Deviation in the Group Where Implant Was Inserted Manually	
	No. of Implants	Values in mm	No. of Implants	Values in mm
Suzuki and Suzuki, 2007 [34]	120	2.0 ± 0.4 mm	20	10.5 ± 3.5 mm
Rashid et al., 2021 [35]	25	0.69 ± 0.02 mm	25	1.44 ± 0.10 mm
Lingling Qiu et al., 2012 [38]	20	0.28 ± 0.23 mm (mesiodistal) 0.33 ± 0.25 mm (vertical)	10	0.81 ± 0.61 mm (mesiodistal) 0.78 ± 0.49 mm (vertical)

Table 4. Differences in apical deviation to the "gold standard line" of mini-implants inserted with the use of 3D surgical guides and mini-implants inserted manually or with a wire guide.

Author and Year	Deviation in the Group with the Use of Surgical Guide		Deviation in the Group Where Implant Was Inserted Manually or with Wire Guide	
	No. of Implants	Values in mm/Root Contact Rate	No. of Implants	Values in mm/Root Contact Rate
Suzuki and Suzuki, 2007 [34]	120	2.0 ± 0.4 mm	20	10.5 ± 3.5 mm
Suzuki and Suzuki, 2007 [34]	120	2.0 ± 0.4 mm	20	5.3 ± 1.1 mm
Rashid et al., 2021 [35]	25	0.69 ± 0.02 mm	25	1.44 ± 0.10 mm
Mi-Ju Bae, 2013 [37]	25	0.73 mm (0.24–2.07)	20	1.28 mm (0.26–3.81)
Lingling Qiu et al., 2012 [38]	20	0.28 ± 0.23 mm (mesiodistal) 0.33 ± 0.25 mm (vertical)	10	0.81 ± 0.61 mm (mesiodistal) 0.78 ± 0.49 mm (vertical)

Table 5. Differences in apical vertical deviation to the "gold standard line" of mini-implants inserted with the use of a 3D tooth-borne surgical guide and MIs inserted with the use of a mucosa-borne surgical guide.

Author and Year	Deviation in the Group with a Tooth-Borne Surgical Guide		Deviation in the Group with a Mucosa-Borne Surgical Guide	
	No. of Implants	Values in Linear Deviation in mm	No. of Implants	Values in Linear Deviation in mm
Möhlhenrich et al. 2019 [39]	20	0.88 ±0.46 mm	20	1.65 ± 1.03 mm
Möhlhenrich et al. 2020 [40]	20	1.7 ± 1.2 mm	20	1.6 ± 1.5 mm
Kniha et al. 2020 [41]	20	0.10 ± 0.46 mm	20	0.22 ± 0.58 mm

(a) The first comparison

Four studies were included in the meta-analysis. The results are shown in Figure 2. A positive value for the Standardized mean difference indicates a greater efficacy of the surgical guide, whereas a negative value indicates manual insertion.

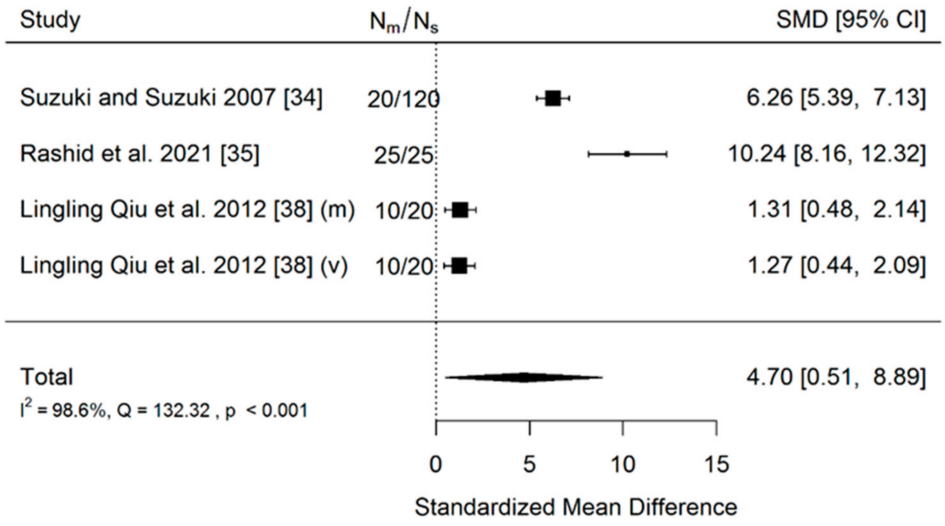

Figure 2. Forest plot of 4 studies in the first comparison performed. N_m—number of mini-implants inserted manually; N_s—number of mini-implants inserted with the use of 3D surgical guide.

Positive values of SMD indicate a greater efficacy of the surgical guide, negative indicates manual insertion. Nm represents the number of implants inserted with 3D surgical guide and Ns represents the number of implants inserted manually. The usage of a surgical guide has great significance ($p = 0.028$) on the positive effect size. Study results are found to be inconsistent—heterogeneity is significant ($p < 0.001$), more than 98% of the variability comes from heterogeneity. All points on the funnel plot (Figure 3) are outside the funnel due to a high heterogeneity, the asymmetry also suggests a publication bias.

(b) The second comparison

There were six results found from the four studies included in the meta-analysis. Mi-Ju Bae, 2013 [37] reported ranges instead of standard deviations, so the range rule [33] was used to estimate standard deviations for this study. The results are shown in Figure 4. A positive value of Standardized mean difference indicates a greater efficacy of surgical guide, negative indicates manual insertion.

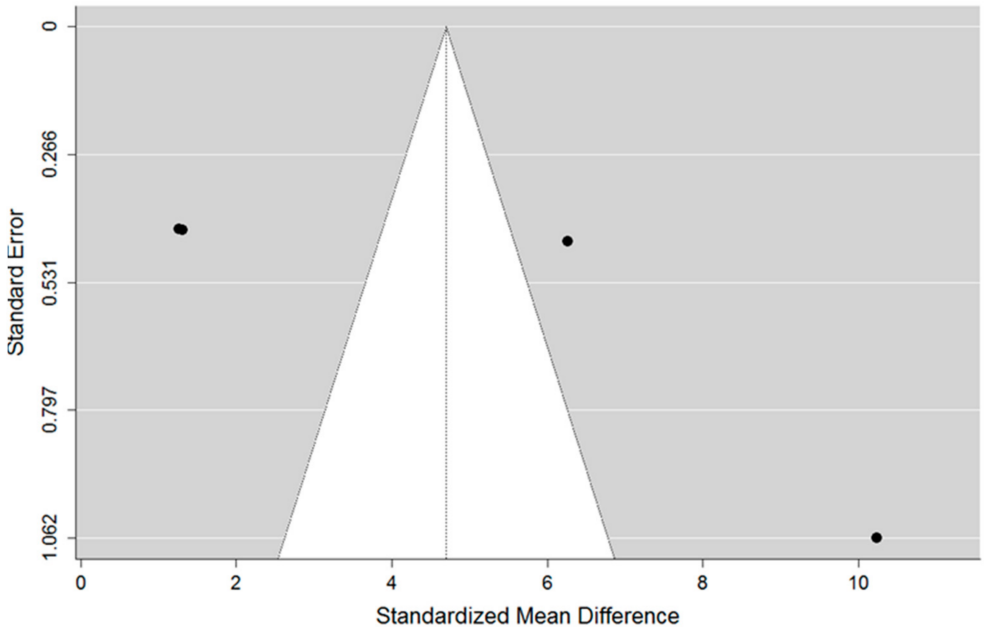

Figure 3. Funnel plot of 4 studies suggests publication bias.

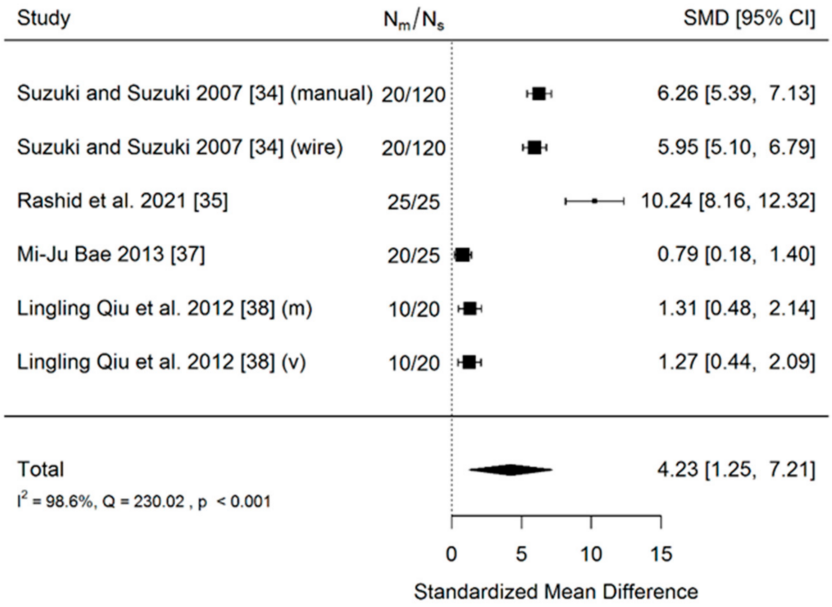

Figure 4. Forest plot of 4 studies of the second comparison. N_m—number of mini-implants inserted manually or with wire guide; N_s—number of mini-implants inserted with the use of 3D surgical guide.

A positive value of SMD indicates a greater efficacy of surgical guides, negative—of manual insertion. Nm—number MI inserted with 3D surgical guide and Ns number of MI inserted with a wire guide or manually. The usage of surgical guides has very a large significant (p = 0.005) positive effect size. Study results are found to be inconsistent—heterogeneity is significant (p < 0.001), more than 98% of the variability derives from heterogeneity. All points on the funnel plot (Figure 5) are outside the funnel due to a high heterogeneity, the asymmetry also suggests a publication bias.