3D Guided Insertion of Orthodontic Titanium Miniscrews

Subjects: Dentistry, Oral Surgery & Medicine

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Orthodontic mini-implants (MIs), also called temporary anchorage devices (TADs), have been considered to be effective tools for intraoral anchorage reinforcement for many years. Their main advantages are their easy application, the possibility to use them at various stages of treatment and the predictability of biomechanical effects.

guided insertion surgical guide orthodontics mini-implant

1. Introduction

Optimal positioning of the screw, taking into account root proximity [1], bone support as well as soft tissue thickness and quality, intends to avoid most complications [2]. For this purpose, surgical templates were introduced. In the glossary of prosthodontic terms, a surgical template is defined as a guide used to assist in the proper surgical placement and angulation of dental implants [3]. The main purpose of the surgical template is to direct drilling and ensure accurate implant placement according to the treatment plan. In order to accurately transfer the implant directly the surgical site, custom surgical templates based on radiological diagnostics have become the treatment of choice [4]. Miniscrew insertion using a surgical guide aims to avoid possible adverse effects or complications. A significant reduction of the failure rate was noticed when using detailed radiological diagnostics of the insertion site, nevertheless a two-dimensional X-ray is considered as sufficient for routine procedures [5]. However, some authors are of the opinion that it is necessary to perform CBCT on or before placing TADs in patients with severe space deficiency, significant tooth crowding, or extraordinary root position on panoramic radiographs [6]. At the turn of the century, wire guides, based on a periapical X-ray gained popularity [7], and they have been used successfully until now by many clinicians, especially if advanced diagnostic tools are unavailable [8]. With the higher availability of both 3D imaging and printing, 3D surgical guides, for which the effectiveness has been well documented in implantology, they have been used more frequently [9][10]. For many clinicians, they seem to present a new avenue, and are even seen as a new remedy for possible complications that may occur during MI insertion. However, they do not take into account key factors such as lack of operator experience, manufacturing costs of template fabrication, the influences of which have already been examined in the case of prosthetic dental implants [11][12]. Therefore, it seems justified to examine the validity of surgical-templates use, which may contribute a discussion on other aspects of guided insertion of temporary anchorage in orthodontics.

2. 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 **Table 1**, **Table 2** and **Table 3**.

Table 1. 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 [13]	120	2.0 ± 0.4 mm	20	10.5 ± 3.5 mm
Rashid et al., 2021 [14]	25	0.69 ± 0.02 mm	25	1.44 ± 0.10 mm
Lingling Qiu et al., 2012 [15]	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 2. 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 [13]	120	2.0 ± 0.4 mm	20	10.5 ± 3.5 mm
Suzuki and Suzuki, 2007 [13]	120	2.0 ± 0.4 mm	20	5.3 ± 1.1 mm
Rashid et al., 2021 [14]	25	0.69 ± 0.02 mm	25	1.44 ± 0.10 mm
Mi-Ju Bae, 2013 [16]	25	0.73 mm (0.24–2.07)	20	1.28 mm (0.26–3.81)
Lingling Qiu et al., 2012 [15]	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 3. 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 [17]	20	0.88 ±0.46 mm	20	1.65 ± 1.03 mm
Möhlhenrich et al. 2020 [18]	20	1.7 ± 1.2 mm	20	1.6 ± 1.5 mm
Kniha et al. 2020 [19]	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 1**. A positive value for the Standardized mean difference indicates a greater efficacy of the surgical guide, whereas a negative value indicates manual insertion.

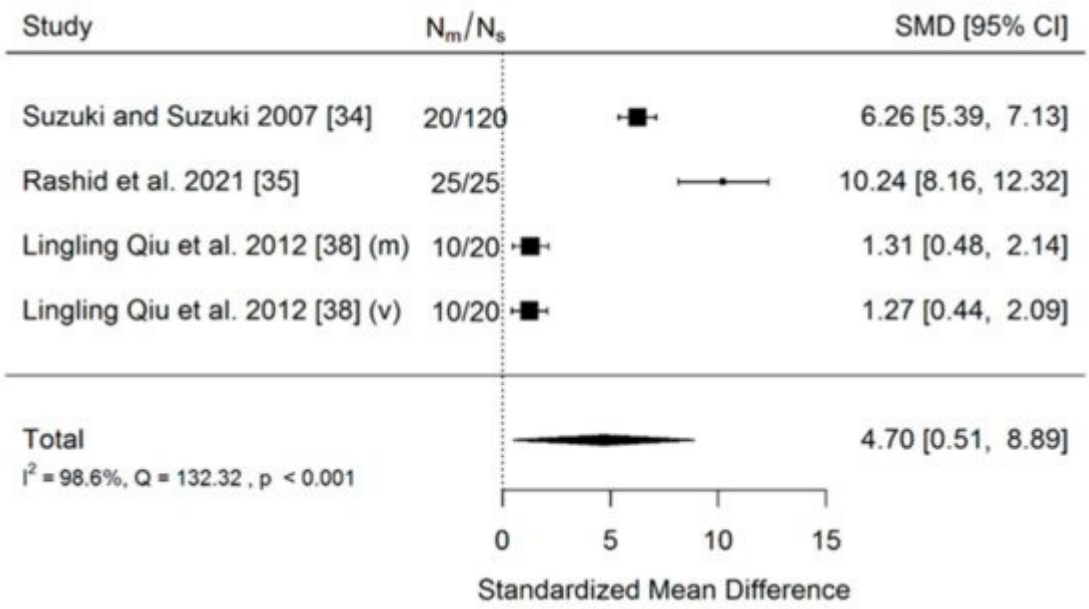

Figure 1. Forest plot of 4 studies in the first comparison performed. N_m—number of mini-implants inserted manually; N_s—number of mini-implants inserted with the use of 3D surgical guide.

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 2**) are outside the funnel due to a high heterogeneity, the asymmetry also suggests a publication bias.

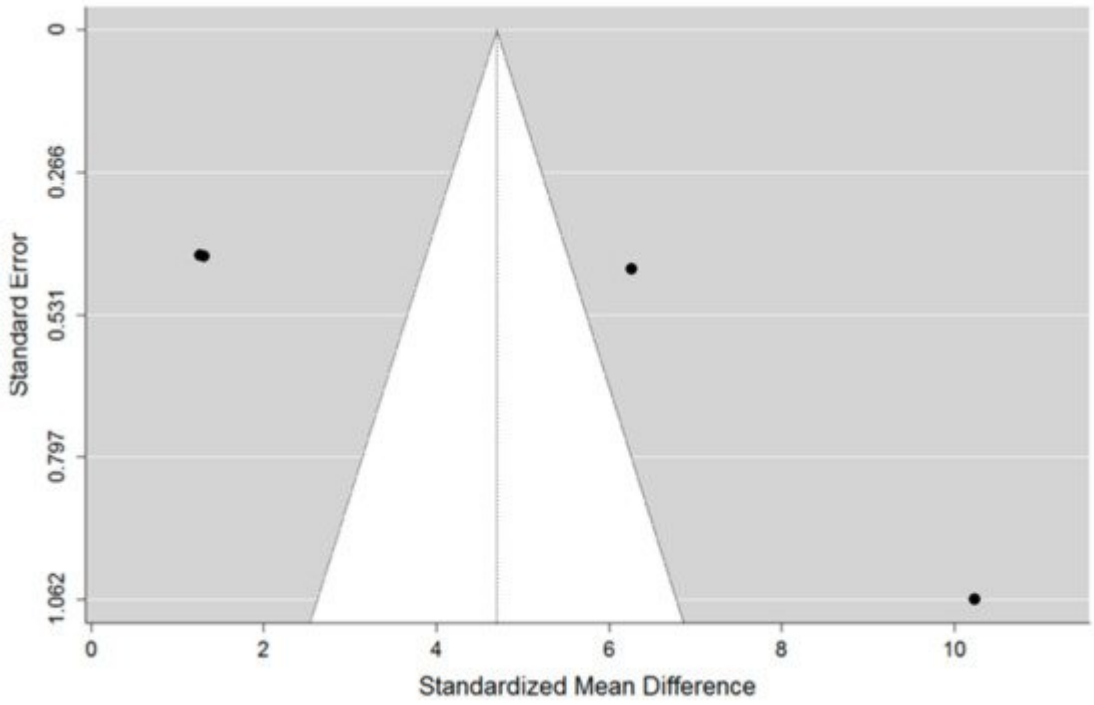

Figure 2. Funnel plot of 4 studies suggests publication bias.

(b) The second comparison

There were six results found from the four studies included in the meta-analysis. Mi-Ju Bae, 2013 [16] reported ranges instead of standard deviations, so the range rule [20] was used to estimate standard deviations for this study. The results are shown in **Figure 3**. A positive value of Standardized mean difference indicates a greater efficacy of surgical guide, negative indicates manual insertion.

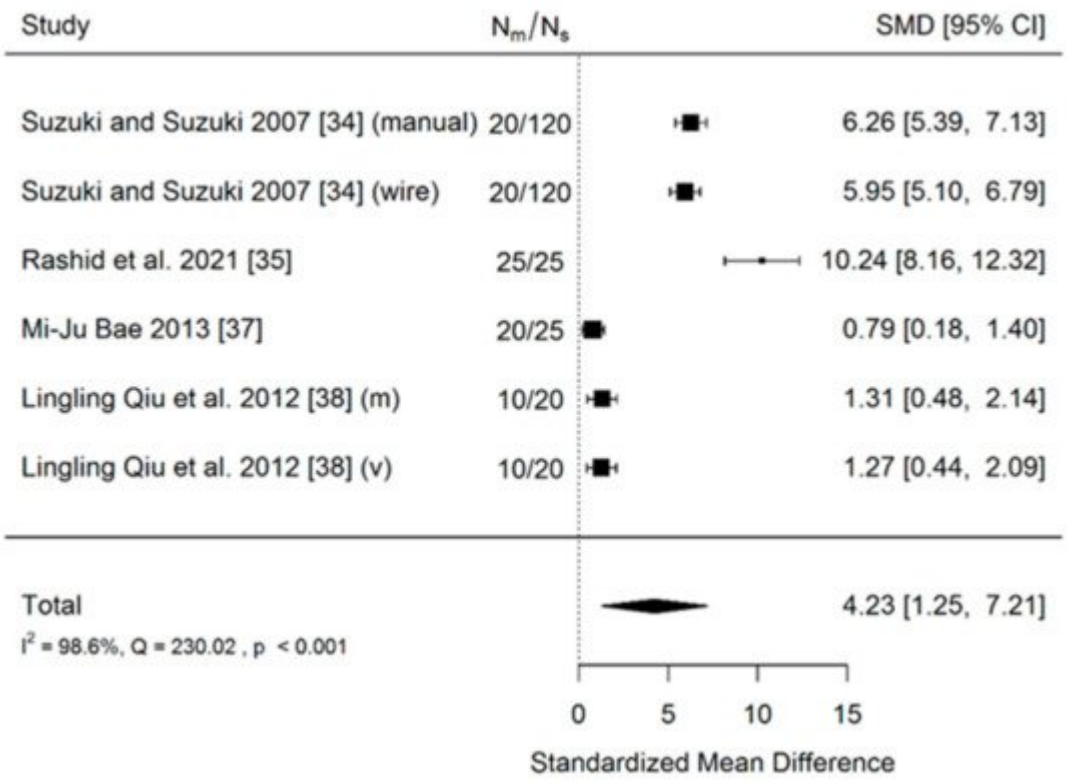

Figure 3. Forest plot of 4 studies of the second comparison. N_m—number of mini-implants inserted manually or with wire guide; N_s—number of mini-implants inserted with the use of 3D surgical guide.

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 4**) are outside the funnel due to a high heterogeneity, the asymmetry also suggests a publication bias.

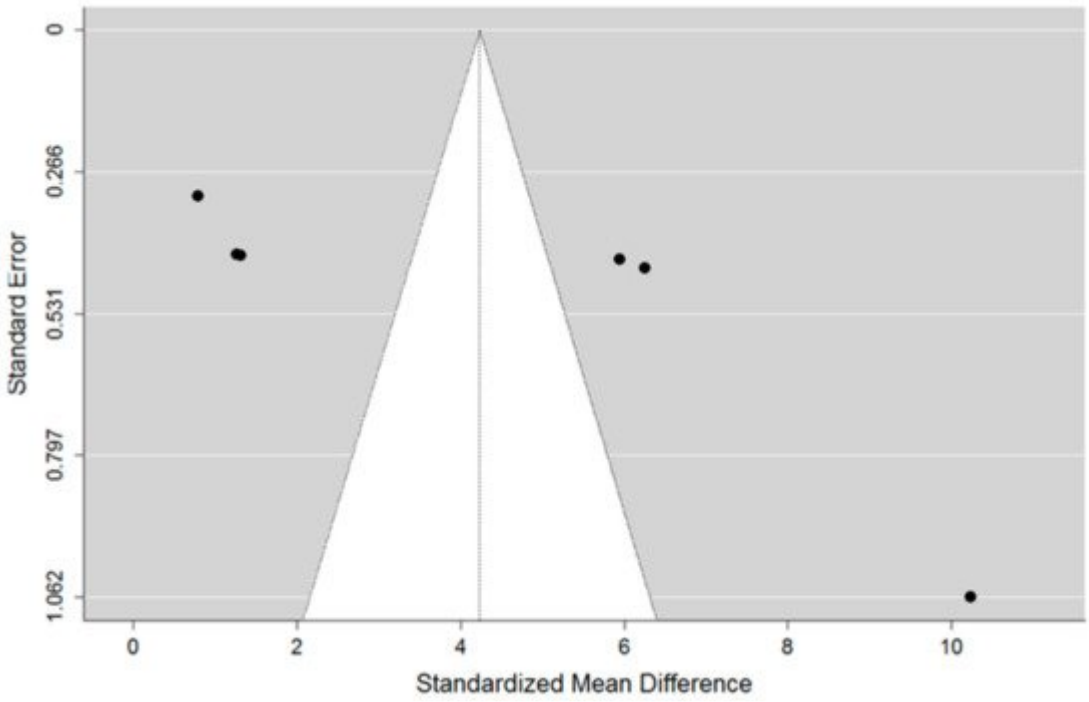

Figure 4. Funnel plot of 4 studies suggests publication bias.

(c) The third comparison

There were 3 included studies in the meta-analysis. The results are shown on **Figure 5**. Positive value of Standardized mean difference indicates a greater efficacy of a tooth-borne surgical guide, negative—of a gingiva-borne surgical guide.

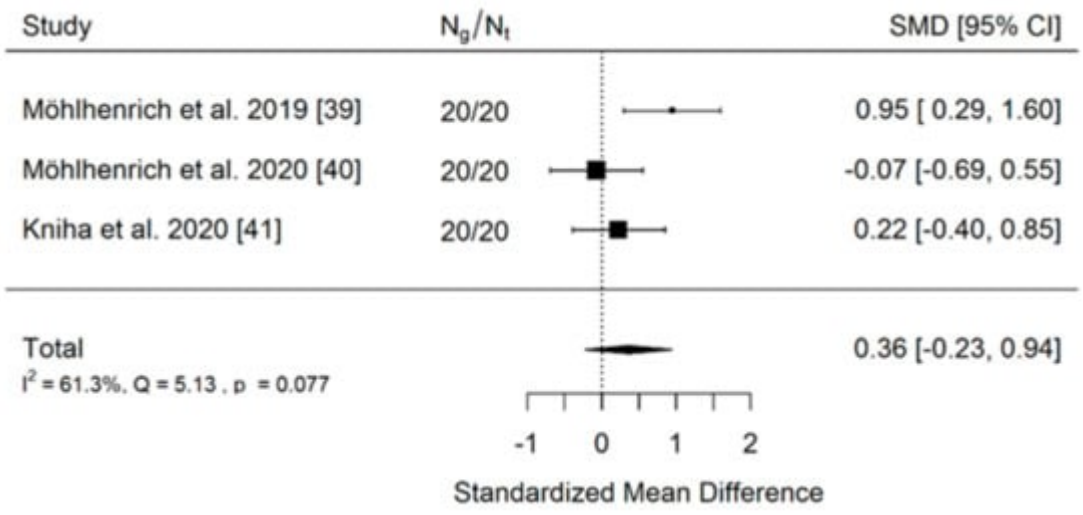

Figure 5. Forest plot of 3 studies of the third comparison performed. N_g—number of mini-implants inserted with gingiva-borne (mucosa-borne) surgical guide; N_t—number of mini-implants inserted with tooth-borne surgical guide.

Positive value of SMD indicates a greater efficacy of the tooth-borne surgical guide, negative—of a gingiva-borne surgical guide. Ng and Nt—number of gingiva-borne and tooth-borne surgical guides. The usage of tooth-borne surgical guide vs. gingiva-borne surgical guide has an insignificant (p = 0.231) positive effect size. Study results are consistent—heterogeneity is insignificant (p = 0.077), around 61% of the variability derives from heterogeneity. The funnel plot (**Figure 6**) does not reveal a publication bias.

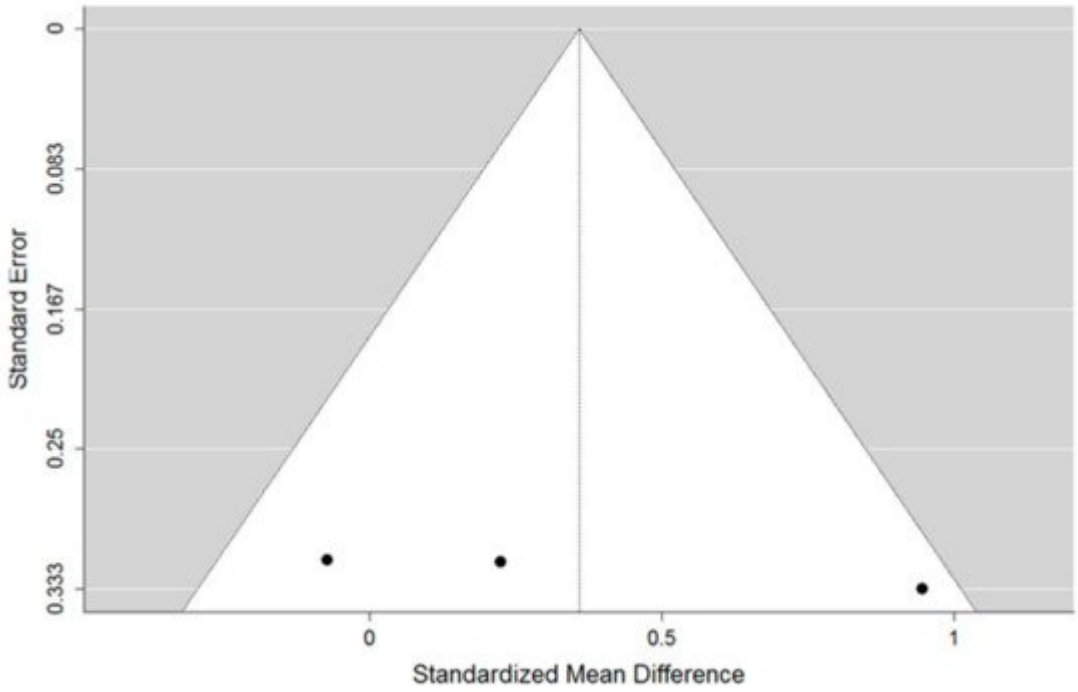

Figure 6. Funnel plot of the third comparison did not reveal any publication bias.

References

1. Moslemzadeh, S.H.; Sohrabi, A.; Rafighi, A.; Kananizadeh, Y.; Nourizadeh, A. Evaluation of interdental spaces of the mandibular posterior area for orthodontic mini-implants with cone-beam computed tomography. J. Clin. Diagn. Res. 2017, 11, ZC09–ZC12.
2. Haddad, R.; Saadeh, M. Distance to alveolar crestal bone: A critical factor in the success of orthodontic mini-implants. Prog. Orthod. 2019, 20, 19.
3. Hickey, J.C. The glossary of prosthodontic terms. J. Prosthet. Dent. 2005, 94, 10–92.
4. Ramasamy, M.; Giri, R.R.; Subramonian, K.; Narendrakumar, R. Implant surgical guides: From the past to the present. J. Pharm. Bioallied Sci. 2013, 5 (Suppl. 1), S98–S102.
5. Kalra, S.; Tripathi, T.; Rai, P.; Kanase, A. Evaluation of orthodontic mini-implant placement: A CBCT study. Prog. Orthod. 2014, 15, 61.
6. Kapila, S.D.; Nervina, J.M. CBCT in orthodontics: Assessment of treatment outcomes and indications for its use. Dentomaxillofac. Radiol. 2015, 44, 20140282.

7. Bae, S.-M.; Park, H.-S.; Kyung, H.-M.; Kwon, O.-W.; Sung, J.-H. Clinical application of micro-implant anchorage. J. Clin. Orthod. 2002, 36, 298–302.
8. Felicita, A.S. A simple three-dimensional stent for proper placement of mini-implant. Prog. Orthod. 2013, 14, 45.
9. D’Souza, K.M.; Aras, M.A. Types of implant surgical guides in dentistry: A review. J. Oral Implantol. 2012, 38, 643–652.
10. Pillai, S.; Upadhyay, A.; Khayambashi, P.; Farooq, I.; Sabri, H.; Tarar, M.; Lee, K.T.; Harb, I.; Zhou, S.; Wang, Y.; et al. Dental 3D-printing: Transferring art from the laboratories to the clinics. Polymers 2021, 13, 157.
11. Simon, H.; Heather, J.C.; Lianshan, L.; Scott, L.; Wook, -J.S. Effect of surgical guide design and surgeon’s experience on the accuracy of implant placement. J. Oral Implant. 2012, 38, 311–323.
12. Ravidà, A.; Barootchi, S.; Tattan, M.; Saleh, M.H.A.; Gargallo-Albiol, J.; Wang, H.L. Clinical outcomes and cost effectiveness of computer-guided versus conventional implant-retained hybrid prostheses: A long-term retrospective analysis of treatment protocols. J. Periodontol. 2018, 89, 1015–1024.
13. Suzuki, E.Y.; Suzuki, B. Accuracy of miniscrew implant placement with a 3-dimensional surgical guide. J. Oral Maxillofac. Surg. 2008, 66, 1245–1252.
14. Rashid, A.; El Feky, H.; Issa, N. Accuracy of miniscrew insertion using a customized printed three-dimensional surgical guide (a comparative split mouth study). Egypt. Dent. J. 2021, 67, 109–118.
15. Qiu, L.; Haruyama, N.; Suzuki, S.; Yamada, D.; Obayashi, N.; Kurabayashi, T.; Moriyama, K. Accuracy of orthodontic miniscrew implantation guided by stereolithographic surgical stent based on cone-beam CT–derived 3D images. Angle Orthod. 2012, 82, 284–293.
16. Bae, M.-J.; Kim, J.-Y.; Park, J.-T.; Cha, J.-Y.; Kim, H.-J.; Yu, H.-S.; Hwang, C.-J. Accuracy of miniscrew surgical guides assessed from cone-beam computed tomography and digital models. Am. J. Orthod. Dentofac. Orthop. 2013, 143, 893–901.
17. Möhlhenrich, S.C.; Brandt, M.; Kniha, K.; Bock, A.; Prescher, A.; Hölzle, F.; Modabber, A.; Danesh, G. Suitability of virtual plaster models superimposed with the lateral cephalogram for guided paramedian orthodontic mini-implant placement with regard to the bone support. Eignung virtuell überlagerter Situationsmodelle und korrespondierender Fernröntgenseitenaufnahmen zur schablonengeführten Mini-Implantat-Insertion unter Berücksichtigung des Knochenangebots. J. Orofac. Orthop. 2020, 81, 340–349.
18. Möhlhenrich, S.C.; Brandt, M.; Kniha, K.; Prescher, A.; Hölzle, F.; Modabber, A.; Wolf, M.; Peters, F. Accuracy of orthodontic mini-implants placed at the anterior palate by tooth-borne or gingiva-borne guide support: A cadaveric study. Clin. Oral Investig. 2019, 23, 4425–4431.

19. Kniha, K.; Brandt, M.; Bock, A.; Modabber, A.; Prescher, A.; Hölzle, F.; Danesh, G.; Möhlhenrich, S.C. Accuracy of fully guided orthodontic mini-implant placement evaluated by cone-beam computed tomography: A study involving human cadaver heads. Clin. Oral Investig. 2021, 25, 1299–1306.
20. Hein, J.L. Discrete Structures, Logic, and Computability, 2nd ed.; Jones and Bartlett Publishers, Inc.: Sudbury, MA, USA, 2002.