Success rates of two techniques of orthodontic microimplants placement. A prospective study

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ABSTRACT

Objectives: To compare success rates between orthodontic microimplants (OMIs) inserted into maxillary and/or mandibular bone with self-drilling (SD) and pre-drilling (PD) techniques and to study whether the success rate of these techniques is affected by patients gender or not.

Methods: Forty young patients equally divided into 2 groups of males and females were randomly selected among orthodontic patients at orthodontic department, Jordanian Royal Rehabilitation Centre. A total of 120 OMIs were used on a split-mouth basis. All subjects received different microimplant insertion technique on either side of his/her maxilla and/or mandible. Being loaded immediately with an average force of 50 grams, stability of the OMIs was observed for a period of 12 weeks after the insertion. Fracture or loosening of the microimplant during this period was considered as failure. The number of the succeeded and failed microimplant was then analysed statistically for the needed objectives at $P<.05$.

Results: There were no statistical differences between the overall success rates of each insertion technique. Also, there were no statistical differences between the 2 techniques in each jaw and that no one technique showed superiority in the success rates as performed in any of the jaws. Whether performed for a male or a female, there were no significant differences in the success rates for each insertion techniques.

Conclusion: Neither the technique of microimplant insertion, nor the patient's gender or the area of insertion of either maxillary or mandibular jaws showed any differences in the success rates of the microimplant at the end.

Keywords: Self-drilling, Pre-drilling, Microimplant, Success rate.

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Introduction

Orthodontic microimplants (OMIs) are currently considered as well established skeletal anchorage systems as they provide extraordinary results in anchorage control with satisfactory patient comfort. Since these devices can substitute other extra and intra-oral resources which rely mainly on patient compliance, they are highly recommended in cases with complex orthodontic problems or when the patient presents with minimal teeth at which the use of conventional systems will be worthless.[1,2]
However, the success rate of these microimplants still needs to be optimized, and for this; many researchers have investigated the risk factors for their failure in an attempt to improve their stability into bone. Factors related to the microimplant itself, bone, and insertion techniques, have been found to affect its stability.[3-5]

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As bone factors -density and thickness of cortical bone mainly- are patient related and cannot be modified, much of the research has been directed toward improvement of the OMI configuration and the techniques used to insert them into the bone.

The procedure of the OMI insertion is mainly performed by 2 techniques; self-drilling (SD) which involves direct drilling of the microimplant into bone and the other technique is pre-drilling (PD) which calls for a preceding step of pilot hole drilling with a diameter and length of 0.2-0.5mm less than that of the microimplant before the insertion surgery.(6) The success rate of each technique was found to be conflicting.(7-9) While some researchers found no differences between both techniques,(10-12) others reported the superiority of the SD technique over the PD technique in terms of the success rate.(7,13,14) This might be a subsequent to the potential disadvantages reported for the PD technique such as damage to nerves and roots, drill bit breakage, thermal necrosis and the more time needed to perform compared to the SD technique with less operative time needed, reduced bone damage and patient discomfort particularly in the region of thin cortical bone areas.(7,15,16) However, such prognosis of the techniques might be affected by several factors among which operator experience, area of the insertion -whether maxillary or mandibular bone- and gender of the patient receiving the microimplants might be encountered.(6)

In this split-mouth clinical study, we aimed to compare comprehensively the success rates between OMIs inserted into either sides of maxillary and/or mandibular bone with SD and PD techniques and to study whether the success rate of these techniques is affected by patients gender or not.

METHODS

The study protocol was approved by the human research ethics committee of the Jordan royal medical services. Forty patients; 20 females (Mean age: 17.75, SD: 1.92 years) and 20 males (Mean age: 16.90, SD: 1.80 years) were randomly selected among orthodontic patients at orthodontic department, Royal Rehabilitation Center, Royal Medical Services, Amman Jordan. Simple randomization using a computer generated random selection was performed to choose the subjects among a total of 70 patients. Informed consent was obtained for each patient. The criteria for patients' selection focused on those young patients presented seeking orthodontic treatment with no systemic illnesses, good oral hygiene, no history of previous orthodontic treatment or any previous extractions and classified as a high anchorage demanding case to use the OMIs as skeletal anchorage.

A total of 120 OMIs (SH 1413-07, Dentos Inc., Daegu, Korea) were used on a split-mouth basis to accurately investigate the needed objectives of this study with standardization of the microimplants, area of insertion and the insertion techniques utilized at one side of each arch or between arches and then to compare this with those for the other side and jaw. All subjects received different microimplant insertion technique on either side of his/her maxilla and/or mandible. Based on the available data concerning the safest areas for OMIs insertion,(17) the 1.4mm diameter and 7mm length microimplants were inserted into the maxillary arch between the first molars and second premolars while in the mandible, between the first and second molars. For all OMIs used, the SD technique was used for insertion at the right side of the patients' jaws and the PD technique at the left side. All subjects received OMIs in their upper arches while only half of them had received the microimplants in their lower jaws as the clinical indications for the use of the absolute anchorage concept necessitated. (Table I)

Table I: Distribution of OMIs insertion techniques and numbers with gender used in the study.

Insertion technique	Maxillary OMIs	Mandibular OMIs
Self-drilling (Right jaw side)	40(M:20, F: 20)	20(M:10, F:10)
Pre-drilling (Left jaw side)	40(M:20, F: 20)	20(M:10, F:10)

The cases selected for treatment necessitated the use of microimplants for the purpose of absolute anchorage demands such as cases that need correction of class II buccal relation by either non-extraction- by full arch distalization- or by retraction of the anterior teeth to close extraction spaces of 1^{st} premolars, cases with bimaxillary dentoalveolar protrusion and severe crowding cases.

Superficial infiltration anaesthesia was given at the patient's insertion site before microimplant insertion. Based on the recommended protocols to optimize their success,[18,19] the microimplants were then inserted with angled directions of 30-40º and 20-60º compared to axes of teeth in the maxillary and mandibular buccal attached gingival areas respectively just below the connection between the attached gingiva and alveolar mucosa. For the PD OMIs, a pilot hole of 1.1mm in diameter was drilled under copious amount of normal saline irrigation using a speed reduction contra-angled handpiece of 400-600rpm and then the microimplant was inserted gently with the aid of a screw hand-driver. 2 periapical X-ray views were taken for each microimplant using cone shift technique to assess its position and relation to neighbouring vital structures (Figure 1).

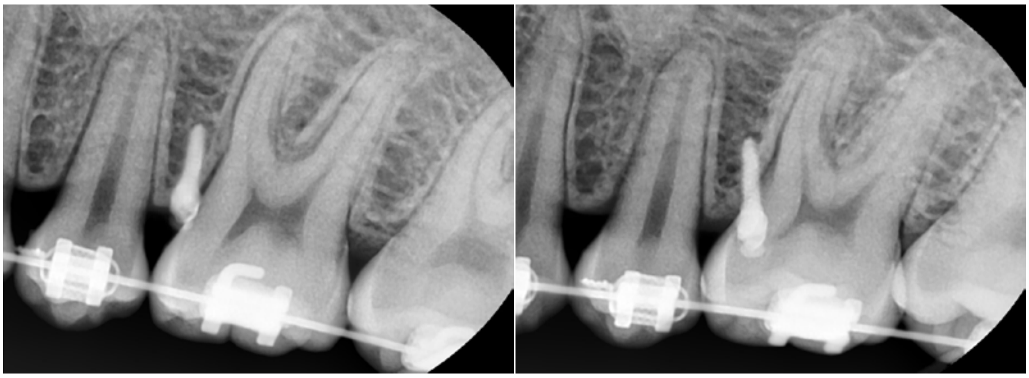

Fig 1: Periapical X-ray views using the cone shift technique to assess the position of the microimplant.

Being loaded immediately with an average force of 50 grams by the aid of elastic super thread (Rocky mountain morita, Japan), stability of the OMIs was observed for a period of 12 weeks at intervals of 1, 2, 4, 8 and 12 weeks after the insertion at which forces of 100 and 200gs were added for all OMIs at the 1st and 8th weeks respectively for the needed orthodontic movements.
A Dontrix force gauge (Orthodontic supply & equipment Co., Inc. Gaithersburg, USA) was used to measure the forces applied. Fracture or loosening of the microimplant during this period was considered as failure. All procedures were performed by one orthodontist for the purpose of avoiding inter-operators differences.
Supportive oral hygiene measures were advised and the patients were asked to call for any problem that could evoke after the microimplants insertion. The number of the succeeded and failed microimplants was then analysed.

Differences in the success rate of all microimplants between both techniques were evaluated. The impact of the area of insertion –either maxilla or mandible- and the gender differences on the success rate of the 2 insertion techniques were also investigated.
The significant differences between the success rates of the 2 OMI insertion techniques as inserted into the maxillary and/or mandibular areas and the gender differences were analysed by chi-square test with Fisher's exact analysis. All statistical tests were performed at $P < 0.05$ level of significance using the statistical software SPSS version 21 (IBM Corp., Armonk, NY, USA).

RESULTS

The numbers of the OMIs succeeded and failed with the different techniques and area of insertion are shown in Table II. The total success rate of all microimplants was 90%. All microimplants failure was encountered at the 1st week check visit. There was no statistical difference between the overall successes rates of each insertion technique although the SD group showed a slightly higher rate of 91.7% compared to the PD (88.3%).
This was also the same for the comparison between the 2 techniques performed in either maxillary or mandibular areas.
Although the success rate was higher for the SD group in the maxilla, and the PD group in the mandible, there were no statistical differences between the 2 techniques in each jaw. Also, no one technique showed significant difference in the success rates whether performed in the maxillary or mandibular bone.
The results found for the comparison between the 2 techniques performed relative to male and female differences are shown in Table III.

No statistical differences were found between the success rates of microimplants as inserted for either males or females. Whether performed for a male or a female, there were no significant differences in the success rates for each insertion techniques.

Table II: Comparison of OMIs success and failure according to technique and area of insertion.

OMI Group	N	Success	Failure	Success %	*Sig.**	
Total	120	108	12	90.00%		
SD	60	55	5	91.70%	0.381	
PD	60	53	7	88.30%		
Maxillary						
SD	40	37	3	92.50%	1.000	0.390^
PD	40	36	4	90.00%		
Mandibular						
SD	20	17	3	85.00%	1.000	
PD	20	18	2	90.00%		1.000^^

*^Results of significance test between SD technique in both jaws. ^^Results of significance test between PD technique in both jaws. N: Number of OMIs. *Significance at level of P<.05 using Fisher's exact analysis.*

Table III: Comparison of success and failure between the 2 techniques as related to the subjects gender.

OMI Group	N	Success	Failure	Success %	*Sig.**
Males	60	54	6	90.00%	1.000
Females	60	54	6	90.00%	
SD					
Males	30	28	2	93.30%	1.000
Females	30	27	3	90.00%	
PD					
Males	30	26	4	86.70%	1.000
Females	30	27	3	90.00%	

***N:** Number of OMIs. *Significance at level of P<.05 using Fisher's exact analysis.*

DISCUSSION

In this study we aimed to analyze the relation between the success rate of the SD and PD techniques that are used to insert OMIs in the daily orthodontic practice. The microimplants size and configuration, areas of insertion, loaded forces and the clinician who performed the procedures were standardized to accurately investigate the success rates of both techniques.

The overall success rate of the OMIs inserted by either techniques in this study was 90%, within the average rate of 80.0%–93.6% reported by Park et al.(20) Such relatively high rate might be related to the clinician expertise and the high patients' compliance to the treatment stages encountered during the microimplants observation period.

While some studies reported that the SD technique has higher success rate compared to the PD,(7,13,14) in this study, we found that although the success rate of the SD technique was higher than that of the PD, statistically; there was no difference as was reported by many other researches.(10-12)

The comparison of the success rates between the OMI insertion techniques is contingent with mechanical and biomechanical consequences of performing each one. Motoyoshi and his colleagues (3) have proposed an optimal insertion torque range of 5-10 Ncm for which the success rate of the OMI could be maximized. Within this range, in areas of thin and less density bone, the insertion torque should be optimized to augment the OMI stability, while in areas of thicker and denser cortical bone, the torque values should be as smaller as possible to reduce stresses and related microdamage.

Compared to the PD technique; the SD procedure is simpler, allowing insertion of the OMI into bone without predrilling. In spite of this advantage, if the bone is dense or thick, excessive placement torque can cause overcompression of the cortical bone, deformation of the surrounding microstructure and eventual cracking with the risk of bone resorption around the microimplant.(10,11) On the other hand, and to overcome these problems, the PD technique which necessitates the drilling of a pilot hole as a pre-requisite for the OMI insertion may avoid such excessive torques in these areas. However, performing this procedure might result in overheating of the bone surrounding the hole during drilling, and poor primary stability caused by over-drilling.(8) Surprisingly, Yadav et al(21) found no differences in the microdamage of bone between either techniques. For all of these, and generally speaking, it cannot be concluded that inserting an OMI with one technique will be more successful than the other and that other factors that might affect the accuracy of performing each technique such as clinician experience should not be overlooked.

Previous reports found that microimplants which inserted into mandibular buccal areas had lower success rate compared to those inserted into maxilla due to abnormally elevated insertion torque values as related to bone quality and quantity.(20,22,23) However, we found that performing any of the 2 techniques in the same jaw was not significantly different. Moreover, there was no superiority of either technique to be performed in one jaw over the other. This could be explained by the fact that in spite of the differences in the cortical bone thickness and density, the performance of the surgical procedures with standardized steps of gentle force of insertion in the SD technique and avoiding the overdrilling and overheating of the bone using copious amounts of irrigation and the use of the speed reduction handpiece in the PD technique might contributed to end up with almost similar success rates.

Concerning the relation between the gender and the microimplant insertion techniques, our results failed to show any relation as the overall success rate between males and females was not significantly different. Also, no one technique showed any preference to be performed in either sex. While these results might disagree with what was found by Manni et al(24) of that females were found to have a lower success rate with microimplants inserted by the PD technique compared to males, our results coincide well with the majority of researches performed concerning this issue and found no difference.(20,25-27)

For the sake of efficiency and effectiveness of orthodontic treatment with OMIs, We recommend starting the insertion procedure of the OMI by the SD technique even in areas of thick and dense bone. However, if much resistance was encountered during the insertion, modifying the technique to the PD one might be considered.

CONCLUSIONS

The success rates of the SD and PD OMI insertion techniques were compared clinically according to different sites of insertion of the maxillary and/or mandibular bones of male and female young orthodontic patients and found that whatever the area of insertion of either maxillary or mandibular areas and whatever the patient's gender, both technique showed no differences in the success rates at the end, and that performing either of them in a professional way will not have any superior effects on the stability of the microimplant over the other.

REFERENCES

1. **Carano A, Velo S, Leone P, Siciliani G.** Clinical applications of the miniscrew anchorage system. J Clin Orthod Jan 2005; 39: 9-24.
2. **Wiechmann D, Meyer U, Büchter A.** Success rate of mini and micro-implants used for orthodontic anchorage: a prospective clinical study. Clin Oral Implants Res 2007; 18: 263-7.
3. **Motoyoshi M, Hirabayashi M, Uemura M, Shimizu N.** Recommended placement torque when tightening an orthodontic mini-implant. Clin Oral Implants Res 2006; 17:109–14.
4. **Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T.** Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Orthod Dentofacial Orthop 2003; 124:373–8.
5. **Motoyoshi M, Yoshida T, Ono a. Shimizu N.** Effect of cortical bone thickness and implant placement torque on stability of orthodontic mini-implant. Int J Oral Maxillofac Implants 2007; 22:779–84.
6. **Chen Y, Kyung HM, Zhao WT, Yu WJ.** Critical factors for the success of orthodontic mini-implants: A systematic review. Am J Orthod Dentofacial Orthop 2009; 135:284-91.
7. **Kim JW. Ahn SJ, Chang YI.** Histomorphometric and mechanical analyses of the drill-free screw as orthodontic anchorage. Am J Orthod Dentofacial Orthop 2005; 128:190-4.
8. **Heidemann W, Gerlach KL, Grobel KH, Kollner HG.** Drill free screws: a new form of osteosynthesis screw. J Craniomaxillofac Surg 1998; 26:163-8.
9. **Wilmes B, Drescher D.** Impact of bone quality, implant type, and implantation site preparation on insertion torques of mini- implants used for orthodontic anchorage. Int J Oral Maxillofac Surg 2011; 7:697–703.
10. **Alharbi H, Almuzian M, Bearn D.** Miniscrews failure rate in orthodontics: systematic review and meta-analysis. Eur J Orthod 2018 Sep; 40(5):519–30.
11. **Yi J, Ge M, Li M, Li C, Li Y, Li X, Zhao Z.** Comparison of the success rate between self-drilling and self-tapping miniscrews: a systematic review and meta-analysis. Eur J Orthod 2017 Jun 1;39(3):287-93.
12. **Son S, Motoyoshi M, Uchida Y, Shimizu N.** Comparative study of the primary stability of self-drilling and self-tapping orthodontic miniscrews. Am J Orthod Dentofacial Orthop 2014 Apr;145(4):480-5.

13. **Chen Y, Shin HI, Kyung HM.** Biomechanical and histological comparison of self-drilling and self-tapping orthodontic microimplants in dogs. Am J Orthod Dentofacial Orthop 2008; 133: 44-50.
14. **Wu X, Deng F, Wang Z, Zhao Z. Wang J.** Biomechanical and histomorphometric analyses of the osseointegration of microscrews with different surgical techniques in beagle dogs. Oral Surg Oral Med Oral Path Oral Rad Endo 2008; 106: 644-50.
15. **Hibi H, Ueda M, Sakai M, Ikemori Y.** Orthodontic anchorage system using a locking plate and self-drilling screws. J Oral Maxillofac Surg 2006; 64:1173-5.
16. **Wawrzinek C, Sommer T, Fischer-Brandies H.** Microdamage in cortical bone due to the overtightening of orthodontic microscrews. J Orofac Orthop 2008; 69:121-34.
17. **Park J, Cho HJ.** Three-dimensional evaluation of interradicular spaces and cortical bone thickness for the placement and initial stability of microimplants in adults. Am J Orthod Dentofacial Orthop 2009; 136(3):314.e1-12.
18. **Park HS.** The use of microimplant as orthodontic anchorage. Seoul, Korea: Nare; 2001.
19. **Park HS, Bae SM, Kyung HM, Sung JH.** Micro-implant anchorage for treatment of skeletal Class I bialveolar protrusion. J Clin Orthod 2001; 35:417-22.
20. **Park HS, Jeong SH, Kwon OW.** Factors affecting the clinical success of screw implants used as orthodontic anchorage. Am J Orthod Dentofacial Orthop 2006;130:18–25.
21. **Yadav S, Upadhyay M, Liu S, Roberts E, Neace W, Nanda R.** Microdamage of the cortical bone during mini-implant insertion with self-drilling and self-tapping techniques: A randomized controlled trial. Am J Orthod Dentofacial Orthop 2012; 141:538-46
22. **Chen YJ, Chang HH, Huang CY, Hung HC, Lai EH, Yao CC**. A retrospective analysis of the failure rate of three different orthodontic skeletal anchorage systems. Clin Oral Implants Res 2007; 18:768-75.
23. **Lim HJ, Eun CS, Cho JH, Lee KH, Hwang HS.** Factors associated with initial stability of miniscrews for orthodontic treatment. Am J Orthod Dentofacial Orthop 2009; 136: 236-42.
24. **Manni A, Cozzani M, Tamborrino F.** Factors influencing the stability of miniscrews. A retrospective study on 300 miniscrews. Eur J Orthod 2010; 33:388-95.
25. **Motoyoshi M, Matsuoka M, Shimizu N.** Application of orthodontic mini-implants in adolescents. Int J Oral Maxillofac Surg 2007; 36:695-9.
26. **Kim YH, Yang SM, Kim S.** Midpalatal miniscrews for orthodontic anchorage: factors affecting clinical success. Am J Orthod Dentofacial Orthop 2010; 137:66-72.
27. **Lee SJ, Ahn SJ, Lee JW.** Survival analysis of orthodontic mini-implants. Am J Orthod Dentofacial Orthop 2010; 137:194-9.