ANALYSIS OF THE USE OF MINI-IMPLANTS AS ANCHORAGE IN ORTHODONTICS AND THEIR PLACEMENT TECHNIQUES

Feruza M. Raxmonova[1*], Mavjuda B. Norova[2], Xayotxon Oxunjonova[1], Ulug'bekova Dildora Ravshanbek qizi[1], Ulugbekov Mirzo Ulugbek Oybek ogli[1], Tukhtasinov Abbosbek Tulkinjon ugli[1], Arzieva Gulnora[3]

[1]Department of Propaedeutic Dentistry, Andijan State Medical Institute, Andijan, Uzbekistan

[2]Department of Therapeutic Dentistry, Bukhara State Medical Institute, Bukhara, Uzbekistan | Email: norovamavzuda7@gmail.com

[3]Department of Obstetrics and Gynecology No.2, Samarkand State Medical University, Samarkand, Uzbekistan | Email: gulnoraborievna111@gmail.com

[1]ORCID: https://orcid.org/0000-0002-5524-688X (Feruza M. Raxmonova)

[2]ORCID: https://orcid.org/0000-0002-1994-8972 (Mavjuda B. Norova)

[1]ORCID: https://orcid.org/0009-0008-8045-7196 | Email: oxunjonovaxayotxon@gmail.com (Xayotxon Oxunjonova)

[1]ORCID: https://orcid.org/0009-0007-2078-3750 | Email: ulugbekovadildora7@gmail.com (Ulug'bekova Dildora Ravshanbek qizi)

[1]ORCID: https://orcid.org/0009-0004-6706-7186 | Email: mirzoulugbekov.1995@gmail.com (Ulugbekov Mirzo Ulugbek Oybek ogli)

[1]ORCID: https://orcid.org/0009-0000-2866-6689 | Email: abbos_ortodont@gmail.com (Tukhtasinov Abbosbek Tulkinjon ugli)

[3]ORCID: https://orcid.org/0009-0008-7867-8395 (Arzieva Gulnora)

***Corresponding Author:** Feruza M. Raxmonova

Abstract

Orthodontic mini-implants, also known as temporary anchorage devices, are widely used in contemporary orthodontics to provide stable skeletal anchorage and improve the predictability of tooth movement. This study aims to analyze the clinical application of mini-implants as anchorage units in orthodontic treatment and to evaluate the main techniques used for their placement. The article discusses the indications for mini-implant use, anatomical placement sites, insertion methods, biomechanical principles, loading protocols, and factors influencing treatment success. Particular attention is given to primary stability, bone quality, soft-tissue condition, insertion angle, and prevention of complications such as implant mobility, inflammation, root contact, and fracture. The findings indicate that orthodontic mini-implants are effective in managing complex tooth movements, including molar intrusion, anterior retraction, distalization, space closure, and correction of malocclusions. Successful treatment outcomes depend on careful case selection, accurate anatomical assessment, proper placement technique, and controlled orthodontic loading. The use of mini-implants as temporary anchorage devices can significantly improve treatment efficiency, reduce dependence on patient compliance, and expand the possibilities of modern orthodontic biomechanics.

Keywords: orthodontics, mini-implants, temporary anchorage devices, skeletal anchorage, placement technique, orthodontic biomechanics

Introduction

Anchorage control is one of the fundamental principles of orthodontic treatment and plays a decisive role in achieving stable and predictable tooth movement. In conventional orthodontics, anchorage has traditionally been obtained through intraoral appliances, extraoral headgear, transpalatal arches, lingual arches, and intermaxillary elastics. However, these methods often depend on patient cooperation and may lead to undesirable reciprocal tooth movement, prolonged treatment duration, and compromised clinical outcomes[1].

The development of skeletal anchorage systems has significantly changed modern orthodontic biomechanics. Among these systems, orthodontic mini-implants, also known as temporary anchorage devices (TADs), have become one of the most important innovations in contemporary orthodontics [2]. Mini-implants are small titanium or titanium-alloy screws temporarily inserted into alveolar or extra-alveolar bone to provide stationary anchorage during orthodontic treatment [3]. Unlike conventional prosthetic implants, orthodontic mini-implants do not require complete osseointegration and can be removed after treatment with minimal trauma [4].

The growing popularity of mini-implants is associated with several clinical advantages. They are relatively simple to place, minimally invasive, cost-effective, and capable of providing immediate or early loading in many clinical situations [5]. In addition, mini-implants reduce dependence on patient compliance and allow orthodontists to perform complex tooth movements that were previously difficult or impossible using traditional anchorage systems [6].

Mini-implants are widely used in cases requiring maximum anchorage control, including anterior en-masse retraction after premolar extraction, molar intrusion, molar distalization, correction of open bite, asymmetry correction, space closure, and management of impacted teeth [7]. Their use has expanded the possibilities of three-dimensional tooth movement and improved treatment predictability in both adolescent and adult patients [8].

Despite their clinical effectiveness, the success of orthodontic mini-implants depends on multiple biological, anatomical, and mechanical factors. Studies show that cortical bone thickness, bone density, insertion torque, implant dimensions, insertion angle, oral hygiene, and soft-tissue condition significantly influence mini-implant stability and survival rate [9]. Primary stability is considered the most important factor because it determines the ability of the mini-implant to withstand orthodontic forces during treatment [10].

Another important aspect is the selection of appropriate placement sites. The interradicular areas between premolars and molars are commonly used because they provide relatively safe access and sufficient cortical bone support [11]. However, extra-alveolar regions such as the infrazygomatic crest, buccal shelf, palate, and retromolar area have gained increasing attention due to their ability to support more complex biomechanics and reduce the risk of root contact [12].

[1] Proffit W. R., Fields H. W., Larson B. E., Sarver D. M. *Contemporary Orthodontics.* 6th ed. Elsevier; 2019.

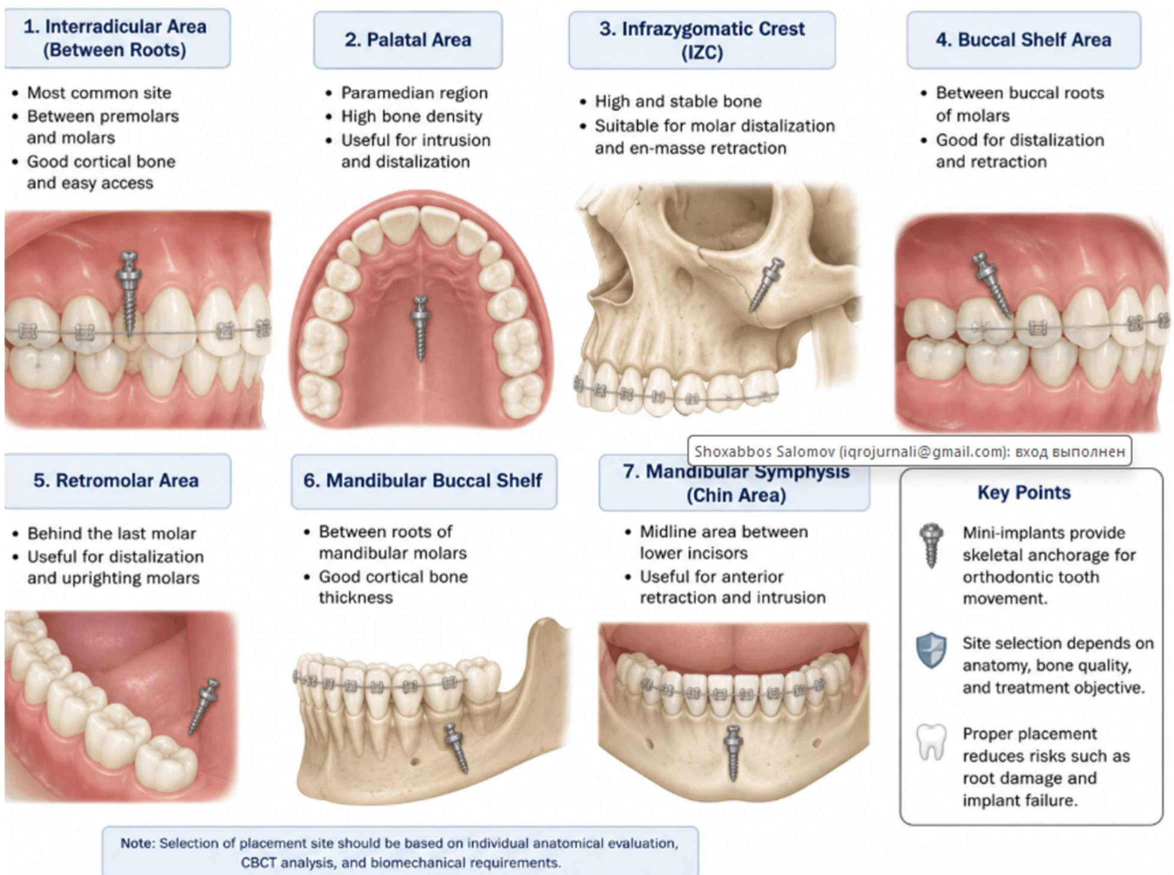

Figure 1. Main Anatomical Placement Sites of Orthodontic Mini-Implants Used for Skeletal Anchorage

Insertion technique also plays a critical role in treatment success. Mini-implants may be inserted using self-drilling or self-tapping methods. Self-drilling systems simplify the procedure and reduce surgical time, whereas self-tapping systems may be preferable in areas with dense cortical bone [13]. Incorrect insertion angle, excessive torque, or placement in movable mucosa may increase the risk of complications such as implant mobility, peri-implant inflammation, root damage, soft-tissue irritation, and implant fracture [14].

Recent advances in digital orthodontics and imaging technologies have further improved the precision of mini-implant placement. Cone-beam computed tomography and digital surgical guides allow clinicians to evaluate anatomical structures more accurately and minimize procedural risks [15]. These technologies contribute to improved safety, better biomechanical planning, and higher success rates.

Although mini-implants are now considered an integral part of modern orthodontic treatment, there is still a need for deeper analysis of their clinical applications, biomechanical advantages, placement protocols, and complications. Understanding the principles of mini-implant anchorage and insertion techniques is essential for optimizing treatment outcomes and reducing failure rates.

Therefore, this article aims to analyze the use of mini-implants as anchorage in orthodontics and to evaluate the main techniques used for their placement, with particular attention to biomechanical principles, clinical effectiveness, and factors influencing treatment success.

Materials and Methods

This article was prepared on the basis of a comprehensive analytical review of contemporary scientific literature devoted to the use of orthodontic mini-implants as temporary anchorage devices and to the analysis of their placement techniques in modern orthodontic practice. Scientific publications, clinical studies, systematic reviews, and evidence-based orthodontic materials related to mini-implant biomechanics, stability, indications, placement protocols, and complications were analyzed.

The study focused on the clinical application of mini-implants in orthodontic treatment, including their use for anchorage reinforcement, anterior retraction, molar intrusion, molar distalization, space closure, correction of open bite, and management of complex malocclusions. The effectiveness of mini-implants was evaluated according to their ability to provide stable skeletal anchorage and reduce unwanted tooth movement.

The main anatomical placement sites were analyzed, including the interradicular areas, palatal region, infrazygomatic crest, mandibular buccal shelf, retromolar area, and mandibular symphysis. These areas were assessed in terms of bone density, cortical bone thickness, soft-tissue condition, anatomical safety, and biomechanical suitability.

Special attention was given to the comparison of self-drilling and self-tapping insertion techniques. Factors influencing primary stability were considered, including implant diameter, implant length, insertion angle, insertion depth, and insertion torque. The relationship between primary stability and clinical success was also analyzed.

Possible complications associated with mini-implant placement were studied, including implant mobility, peri-implant inflammation, soft-tissue irritation, root contact, implant fracture, and anchorage failure. Preventive measures and clinical recommendations for reducing these complications were also evaluated.

The collected data were systematized using analytical, comparative, and descriptive methods. Based on the reviewed materials, the main clinical advantages, limitations, and practical recommendations for the effective use of mini-implants in orthodontics were summarized.

Results

The analysis showed that mini-implants significantly improve anchorage control in orthodontic treatment. Their main advantage is the possibility of obtaining stable skeletal support without relying on reciprocal tooth movement or patient cooperation. This makes them clinically valuable in cases requiring maximum anchorage.

Mini-implants can be used as direct or indirect anchorage. In direct anchorage, orthodontic force is applied directly from the mini-implant to the tooth or dental segment that needs movement. In indirect anchorage, the mini-implant stabilizes a tooth or group of teeth, which then serve as anchorage units. Both methods are effective, but direct anchorage is often preferred in cases requiring precise control of force direction.

The most common placement sites include the interradicular areas between premolars and molars, the infrazygomatic crest, buccal shelf area, palate, retromolar region, and mandibular symphysis. The choice of placement site depends on the treatment objective, anatomical safety, cortical bone thickness, attached gingiva availability, and planned direction of orthodontic force.

Placement technique is one of the key factors determining mini-implant stability. Self-drilling and self-tapping techniques are commonly used. Self-drilling mini-implants are inserted directly into bone without pre-drilling and are often preferred in areas with adequate cortical bone. Self-tapping systems require pilot drilling before insertion and may be useful in dense cortical bone to reduce excessive insertion torque.

Primary stability is essential for clinical success. It is influenced by cortical bone thickness, insertion torque, implant dimensions, and insertion angle. Moderate insertion torque is desirable, because insufficient torque may result in mobility, while excessive torque may increase the risk of microdamage or fracture. Reviews emphasize that mini-implant success depends strongly on initial stability and appropriate loading.

The timing of loading may be immediate or delayed. Many clinical protocols allow early or immediate loading when adequate primary stability is achieved. However, excessive force should be avoided. Light continuous orthodontic forces are generally recommended to reduce the risk of implant mobility and soft-tissue irritation.

The analysis also showed that complications are usually preventable through proper planning. Root contact can be avoided by careful radiographic evaluation and correct angulation. Soft-tissue inflammation can be reduced by placing mini-implants in attached gingiva when possible and maintaining oral hygiene. Failure risk increases when implants are placed in mobile mucosa, areas with insufficient cortical bone, or under excessive orthodontic load.

Table 1. Main Clinical Aspects of Orthodontic Mini-Implants

Aspect	Description	Clinical Importance
Function	Temporary skeletal anchorage	Provides stable support for controlled tooth movement
Placement sites	Interradicular bone, palate, infrazygomatic crest, buccal shelf	Selected according to anatomy and treatment mechanics
Insertion methods	Self-drilling or self-tapping	Determines surgical simplicity and primary stability
Loading	Immediate or delayed	Depends on primary stability and force magnitude
Complications	Mobility, inflammation, root contact, fracture	Reduced by proper planning and technique

Discussion

The findings confirm that mini-implants have changed orthodontic treatment planning by expanding the possibilities of anchorage control. They allow clinicians to perform movements that are difficult or unpredictable with conventional anchorage systems. This is especially important in adult patients, extraction cases, open bite correction, molar intrusion, and patients with reduced compliance.

A major advantage of mini-implants is biomechanical flexibility. By selecting the appropriate placement site, the orthodontist can control the line of force and reduce unwanted side effects. For example, posterior mini-implants may support anterior retraction, while palatal or buccal shelf mini-implants may assist molar distalization or intrusion. This makes mini-implant anchorage highly adaptable to individual treatment needs.

At the same time, successful use of mini-implants requires careful anatomical planning. The clinician must consider root proximity, maxillary sinus position, nasal cavity boundaries, mandibular canal location, and soft-tissue thickness. In complex cases, three-dimensional imaging or surgical guides may improve placement accuracy. Evidence on temporary anchorage devices indicates that placement location and initial stability are among the most important determinants of success.

The choice between self-drilling and self-tapping techniques should depend on bone quality and clinical conditions. Self-drilling techniques simplify placement and reduce surgical time, but they may not be ideal in very dense bone. Self-tapping techniques with pre-drilling may reduce insertion stress in dense cortical areas. Therefore, an individualized approach is required.

Soft-tissue management is another important factor. Placement in attached gingiva is generally more favorable because it reduces inflammation and discomfort. In contrast, placement in movable mucosa may increase the risk of peri-implant irritation and failure. Good oral hygiene and patient instruction are necessary throughout treatment.

Overall, mini-implants are effective and relatively safe when used with proper planning and technique. Their clinical success depends on the interaction between biological, mechanical, and technical factors. Therefore, orthodontists should combine anatomical knowledge, biomechanical planning, and careful postoperative monitoring.

Literature Review

Anchorage control is considered one of the most important factors determining the success of orthodontic treatment. Traditional anchorage methods, including headgear, transpalatal arches, lingual arches and intermaxillary elastics, have been widely used for many years. However, these methods often depend on patient compliance and may lead to unwanted reciprocal tooth movement [1]. Therefore, the search for more stable and predictable anchorage systems has led to the development of skeletal anchorage methods.

Orthodontic mini-implants, also known as temporary anchorage devices, have significantly changed modern orthodontic biomechanics. According to Papadopoulos, skeletal anchorage allows clinicians to obtain stable support directly from bone tissue and perform complex tooth movements with greater precision [2]. Ludwig, Baumgaertel and Bowman emphasized that mini-implants are minimally invasive, relatively simple to place, and can be removed after completion of orthodontic treatment without significant tissue damage [3].

Costa et al. were among the first researchers to describe the use of miniscrews as orthodontic anchorage devices. Their study demonstrated that mini-implants could provide effective temporary anchorage and reduce dependence on conventional anchorage units [4]. Later studies confirmed that mini-implants are effective in anterior tooth retraction, molar intrusion, molar distalization, open bite correction and management of complex malocclusions [5,6].

Several authors have investigated the factors influencing mini-implant success. Motoyoshi et al. noted that insertion torque is one of the key parameters affecting primary stability [7]. Miyawaki et al. reported that implant diameter, bone quality, inflammation around the implant and soft-tissue condition may influence stability and survival rate [8]. Park et al. also emphasized that careful selection of placement site and proper surgical technique are essential for clinical success [9].

The choice of anatomical placement site is widely discussed in the literature. Interradicular areas between premolars and molars are commonly used because of their accessibility and favorable cortical bone thickness. However, extra-alveolar sites such as the infrazygomatic crest and mandibular buccal shelf are increasingly used for complex orthodontic movements, especially molar distalization and total arch movement [10]. These areas reduce the risk of root contact and provide better biomechanical advantages in selected cases.

Insertion technique is another important aspect of mini-implant application. Self-drilling and self-tapping methods are commonly used in clinical practice. Wilmes and Drescher reported that insertion depth, pilot drilling diameter and bone density affect primary stability [11]. Improper insertion angle, excessive torque or placement in movable mucosa may increase the risk of complications such as implant mobility, peri-implant inflammation, root damage and implant fracture [12].

Recent studies also highlight the importance of digital technologies in mini-implant placement. Cone-beam computed tomography allows more accurate assessment of bone thickness, root proximity and anatomical limitations. Kim et al. demonstrated that CBCT-based evaluation may improve placement accuracy and reduce procedural risks [13].

Thus, the literature shows that orthodontic mini-implants are effective temporary anchorage devices that expand the possibilities of modern orthodontic treatment. Their successful use depends on correct indication, anatomical site selection, primary stability, insertion technique, oral hygiene and biomechanical planning. Further studies are needed to optimize placement protocols and improve long-term clinical outcomes.

Conclusion

Orthodontic mini-implants have become one of the most effective and widely used anchorage systems in modern orthodontic practice. Their introduction has significantly expanded the possibilities of orthodontic treatment by providing stable skeletal anchorage, reducing dependence on patient cooperation, and allowing more predictable control of tooth movement.

The analysis shows that mini-implants are especially useful in clinical situations requiring maximum anchorage, such as anterior tooth retraction, molar intrusion, molar distalization, open bite correction, space closure, and management of complex malocclusions. Compared with traditional anchorage methods, mini-implants offer greater biomechanical control and help minimize unwanted reciprocal tooth movement.

The success of mini-implant-supported treatment depends on several important factors, including proper case selection, accurate anatomical assessment, correct choice of placement site, appropriate implant size, insertion angle, primary stability, and controlled orthodontic loading. In addition, the condition of soft tissues, oral hygiene, and prevention of peri-implant inflammation play an essential role in maintaining implant stability throughout treatment.

Both self-drilling and self-tapping placement techniques can be effective when selected according to bone density and clinical requirements. Careful planning, radiographic evaluation, and knowledge of anatomical structures help reduce complications such as root contact, implant mobility, soft-tissue irritation, and fracture.

Thus, orthodontic mini-implants represent a reliable, minimally invasive, and clinically valuable method for improving anchorage control and treatment efficiency. Their proper use can shorten treatment time, improve functional and aesthetic outcomes, and increase the predictability of orthodontic therapy. Further research is needed to optimize placement protocols, improve long-term success rates, and develop more individualized approaches for different clinical cases.

References

1. Proffit W. R., Fields H. W., Larson B. E., Sarver D. M. *Contemporary Orthodontics.* 6th ed. Elsevier; 2019.

2. Papadopoulos M. A. *Skeletal Anchorage in Orthodontic Treatment of Class II Malocclusion.* Elsevier; 2014.

3. Ludwig B., Baumgaertel S., Bowman S. J. *Mini-Implants in Orthodontics: Innovative Anchorage Concepts.* Quintessence Publishing; 2008.

4. Costa A., Raffainl M., Melsen B. Miniscrews as orthodontic anchorage: a preliminary report. *International Journal of Adult Orthodontics and Orthognathic Surgery.* 1998;13(3):201–209.

5. Chen Y., Kyung H. M., Gao L., Yu W. Clinical applications of orthodontic mini-implants. *Journal of Oral Implantology.* 2009;35(2):64–68.

6. Papageorgiou S. N., Zogakis I. P., Papadopoulos M. A. Failure rates and associated risk factors of orthodontic miniscrew implants: a meta-analysis. *American Journal of Orthodontics and Dentofacial Orthopedics.* 2012;142(5):577–595.

7. Maino B. G., Mura P., Bednar J. Miniscrew implants: the spider screw anchorage system. *Seminars in Orthodontics.* 2005;11(1):40–46.

8. Kuroda S., Sugawara Y., Deguchi T., Kyung H. M., Takano-Yamamoto T. Clinical use of miniscrew implants as orthodontic anchorage. *Journal of Clinical Orthodontics.* 2007;41(2):89–97.

9. Motoyoshi M., Hirabayashi M., Uemura M., Shimizu N. Recommended placement torque when tightening an orthodontic mini-implant. *Clinical Oral Implants Research.* 2006;17(1):109–114.

10. 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. *American Journal of Orthodontics and Dentofacial Orthopedics.* 2003;124(4):373–378.

11. Park H. S., Jeong S. H., Kwon O. W. Factors affecting the clinical success of screw implants used as orthodontic anchorage. *American Journal of Orthodontics and Dentofacial Orthopedics.* 2006;130(1):18–25.

12. Chang C., Roberts W. E. Orthodontic extra-alveolar bone screws: concepts and clinical applications. *Orthodontics & Craniofacial Research.* 2019;22(S1):22–26.

13. Wilmes B., Drescher D. Impact of insertion depth and pre-drilling diameter on primary stability of orthodontic mini-implants. *Angle Orthodontist.* 2009;79(3):609–614.

14. Chen Y. J., Chang H. H., Huang C. Y., Hung H. C., Lai E. H., Yao C. C. A retrospective analysis of the failure rate of three different orthodontic skeletal anchorage systems. *Clinical Oral Implants Research.* 2007;18(6):768–775.

15. Kim S. H., Kang S. M., Choi Y. S., Kook Y. A., Chung K. R., Huang J. C. Cone-beam computed tomography evaluation of mini-implant placement in orthodontics. *American Journal of Orthodontics and Dentofacial Orthopedics.* 2010;138(4):439–445.

16. Ritchie C., McGregor S., Bearn D. R. Temporary anchorage devices and the forces and effects on the dentition and surrounding structures during orthodontic treatment: a scoping review. *European Journal of Orthodontics.* 2023;45(3):324–337.

17. Temporary Anchorage Devices in Orthodontics: A Narrative Review of Classification, Design, Biomechanics, Insertion Protocols and Complication Management. *Applied Sciences.* 2025.

18. Temporary Anchorage Devices. *PMC Review Article.*

19. Where You Place, How You Load: A Scoping Review of the Factors Influencing the Effectiveness of Orthodontic Mini-Implants and Temporary Anchorage Devices. *Applied Sciences.* 2025.

20. Temporary anchorage devices in clinical orthodontics. *American Journal of Orthodontics and Dentofacial Orthopedics.*

21. Patients' perceptions and success rate of temporary anchorage devices. *Clinical study.*

22. Mini-screw implants as temporary anchorage devices: orthodontic and pre-prosthetic applications.

23. Anchorage and stability of orthodontic mini implants in relation to placement factors. *Review article.*