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ORIGINAL ARTICLE

Factors affecting success and failure of orthodontic mini-implants: A retrospective review.

Faiza Malik[1], Fiza Khan[2], Sundas Ali[3], Faiza Rana[4], Hooria Haq[5], Mazhar Hussain[6]

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ABSTRACT… Objective: To determine the factors associated with success and failure of orthodontic mini-implant (MI) in orthodontic patients. **Study Design:** Retrospective Review. **Setting:** Department of Orthodontics, Sharif Medical and Dental College. **Period:** September-November 2021. **Material & Methods:** The files and records of all patients from last 3 years fulfilling the selection criteria were reviewed by an orthodontic consultant and two post-graduate residents and data was recorded in a predesigned proforma. All mini-implants were inserted by a single operator (orthodontic consultant) with a hand driven autoclaved screwdriver compatible with Dentaurum Mini-Implant (Tomas Pin©). Length and Diameter of all mini-implants were chosen to be constant with 8mm length and 1.5mm diameter. All patient-related and location-related factors related to success of mini-implant were assessed. **Results:** The success rate in females (85.9%) was higher than in males (69.5%) and there was significant difference between males and females (p=0.023). The TADS inserted in higher bone quality (Q1=95.8%, Q2=94.4%) showed a significant difference (p=0.001) in success rate than those inserted in lower bone quality (Q3=38.1%, Q4=23.1%). **Conclusion:** Bone quality and gender were significant factors, which impact the clinical performance of orthodontic mini-implants. Other patient-related and location-related factors did not significantly impact the success rate of orthodontic mini-implants.

Key words: Anchorage, Location-related Factors, Patient-related Factors, Success Rate, Temporary Anchorage Device (TADS).

INTRODUCTION

In orthodontic treatment, movement of teeth is attained via force system and conversion of mechanical stimulus into biologic response. To achieve differential tooth movement, inter-arch or intra-arch anchorage is required.[1] Anchorage can be classified into three categories; absolute anchorage in which there is no movement of anchored teeth; reciprocal anchorage when two units of teeth move towards each other with equal distance; stationary anchorage when the anchored teeth are allowed to move freely.[2]

Anchorage plays a critical role in orthodontics, and its control is necessary for best results.[3] According to Newton's Third Law of Dynamics 'For every action there is an equivalent opposite reaction.' These reaction forces can move other teeth as well.[4] Controlling these reactionary forces requires the use of anchorage appliances for successful correction of malocclusion that is achieved by dental or skeletal structures of head and neck or by anchors screwed to the jaws. To reinforce anchorage lingual holding arch, trans-palatal arch, Nance palatal button, Class II and Class III elastics, headgear and facemask are used.[5,6]

Bone anchors play critical role in the facilitation of some orthodontic problems. Temporary anchorage devices (TADs) have been introduced in the form of titanium mini screws which have widened the horizon of biomechanics in the field of orthodontics and greatly improved anchorage during orthodontic therapy. Mini screws are used to provide skeletal/absolute anchorage.[7] Linkow

1. BDS, FCPS, BDS, CHPE, Associate Professor Orthodontics, Sharif Medical and Dental College,
2. BDS, Postgraduate FCPS-II Resident Orthodontics, Sharif Medical and Dental College,
3. BDS, Demonstrator Orthodontics, Sharif Medical and Dental College,
4. BDS, Demonstrator Orthodontics, Sharif Medical and Dental College,
5. BDS, Postgraduate FCPS-II Resident Orthodontics, Sharif Medical and Dental College,
6. BDS, Postgraduate FCPS-II Resident Orthodontics, Sharif Medical and Dental College,

Correspondence Address:
Dr. Faiza Malik
Department of Orthodontics
Sharif Medical and Dental College,
dr.faizahash@gmail.com

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was the first researcher to describe use of implant for orthodontic purpose.[8] Later on, Creekmore and Eklund performed maxillary incisor intrusion with the help of titanium screws.[9]

Temporary anchorage devices (TADs) involve miniplates and mini-implants. Mini-implants are mostly used because they are user-friendly, inexpensive, immediately loadable, biocompatible and dimensionally small.[10] Unlike other intraoral and extraoral anchorage appliances, mini-implants do not rely on patient compliance. Mini-implants are placed in patients aged 12 years or above with permanent dentition and cannot be placed in younger patients because of low bone density and unerupted teeth. Orthodontic mini-implants are useful in treatment of cases of dentoskeletal discrepancies including deep bite and open bite.[11] Orthodontic intrusion with TADs provides a conservative treatment approach, avoiding surgical approach in many patients.[12,13]

One of the drawbacks of orthodontic mini-implant is its rate of failure and variability that is reported to lie between 5% and 20%.[14] The factor contributing to their failure are highly unpredictable and vary among different patients. Therefore, probability of failure rate with orthodontic mini-implant in any treatment plan must be accounted for.[14]

The rate of success of orthodontic mini-implant ranges between 80% to 100%.[15] The factors that influence the success rate are patient-related factors (age, sex, oral hygiene), implant-related factors (diameter, length), location-related factors (site of insertion, side of insertion, jaw of insertion, bone quality, type of soft tissue) and operator-related factors (force during insertion, type of loading, angle of insertion).[15]

The aim of this research was to study potential factors involved in the success and failure of orthodontic mini-implant. Orthodontic mini-implant provides superior anchorage, as compared to other devices and efforts must be made to maximize its clinical performance. Identifying the underlying factors affecting their success and failure will help to overcome them during clinical treatment of orthodontic patients. This will lead to optimal treatment duration and better esthetic and functional outcome of orthodontic cases.

MATERIAL & METHODS

This retrospective review involved a total of 130 orthodontic mini-implants inserted in 85 patients requiring skeletal anchorage for orthodontic treatment. Firstly, approval was taken from Sharif Medical Research Center (SMRC) and the Ethical Committee of Sharif Medical and Dental College, Lahore (SMDC/SMRC/200-21). The inclusion criteria was orthodontic patients having mini-implant(s) inserted during fixed orthodontic treatment with complete records such as history and examination proforma, Orthopantomogram, Lateral Cephalogram, Photographs and Dental casts. Orthodontic mini-implant data included mini-implant insertion date, loading date, failure date (if applicable) and mini-implant re-insertion date, loading date, failure date (if applicable). All orthodontic patients with incomplete records or incomplete follow up data after mini-implant insertion and treated with minimum or moderate anchorage were excluded.

Data Collection Procedure

Records of all Patients under treatment for the last 3 years in Department of Orthodontics at Sharif Medical and Dental College, were reviewed. All mini-implants were inserted by single operator, after injecting Local anesthesia (Lignocaine HCL 0.2% with Epinephrine 1:100,000) at the site of insertion of mini-implant. The mini-implant (Figure-1) was inserted directly into the bone with a hand driven Tomas screwdriver compatible with Dentaurum mini-implant (Tomas Pin). Length and Diameter of mini-implant were kept constant at 8mm length and 1.5mm in diameter. Bone quality was assessed and recorded based on tactile perception of operator during MI insertion. After insertion patient was given oral hygiene maintenance instruction to prevent any local inflammation including 0.12% chlorhexidine mouthwash for 2 weeks.

All patient related and location related factors that influence success and failure of mini-implant were assessed.

1. **Patient Related Factors**
   - Age of patient
   i. <20years
   ii. >20years
   - Gender
   i. Male
   ii. Female
   - Oral hygiene
   i. Unsatisfactory- presence of plaque and food debris on one or more teeth or any visible signs of inflammation.
   ii. Satisfactory- absence of debris and inflammation.
2. **Location Related Factors**
   - Jaw of insertion
   i. Maxilla
   ii. Mandible
   - Site of insertion
   i. Buccal
   ii. Lingual
   - Side of insertion
   i. Right
   ii. Left
   - Type of soft tissue
   i. Keratinized mucosa
   ii. Oral mucosa
   - Bone Quality
   i. Q1- homogenous compact bone.
   ii. Q2- thick layer of compact bone surrounding a core of dense trabecular bone.
   iii. Q3- consist of thin layer of cortical bone surrounds a core of dense trabecular bone.
   iv. Q4- thin layer of cortical bone surrounding a core of low-density trabecular bone of poor strength.

The criteria for success of Orthodontic mini-implant was that it should be functionally stable until the end of the treatment with no signs of inflammation or any pathological condition around the MI or until the function for which it is inserted is achieved.

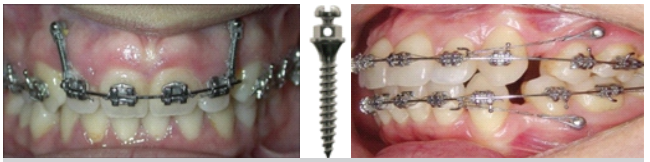

Figure 1: Orthodontic Mini-implants

Data Analysis Procedure

Data was analysed by IBM Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics for all factors were calculated. Chi square test was applied to determine association between success and failure of mini-implants and all other factors. P value < 0.05 will be considered significant.

RESULTS

In this study, orthodontic records of 130 mini-implants inserted in 85 patients, were reviewed, out of which 39 were males and 46 were females with a mean age of 20 years. Regarding patient-related factors (age, gender, malocclusion, oral hygiene) as shown in Table-I, the success rate in patients up to 20 years of age was 81.3% and in patients older than 20 years was 74.0%. The difference in success rate according to age of patients was not statistically significant (p =0.328). The success rate of MI in patients with Class I malocclusion was 81.8%, Class II malocclusion was 80.6% and Class III malocclusion was 57.1%. Malocclusion did not significantly affect success rate of mini-implant (p=0.120). Oral hygiene also showed insignificant statistical differences (p=0.762) between satisfactory and unsatisfactory groups.

Regarding various location related factors (jaw of insertion, side of insertion, site of insertion, bone quality) as shown in Table-II, no statistically significant differences in success rate of orthodontic mini-implants among jaw, site and side of insertion were noted. The MI inserted in greater bone quality (Q1=95.8%, Q2=94.4%) showed a significant difference (p=0.001*) in success rate than those inserted in lower bone quality (Q3=38.1%, Q4=23.1%).

	Age			Gender			Malocclusion				Oral Hygiene		
	>20yrs	<20yrs	P-Value	Male	Female	P-Value	Class I	Class-II	Class-III	P-Value	Good	Poor	P-Value
	%	%		%	%		%	%	%		%	%	
Success	81.3%	74.0%	0.328	69.5%	85.9%	0.023*	81.8%	80.6%	57.1%	0.120	81.1%	72.5%	0.762
Failure	18.8%	26.0%		30.5%	14.1%		18.2%	19.4%	42.9%		15.3%	27.5%	

Table-I. Success Rate of MI with reference to patient related factors

Age	Frequency	%	Success		Success Rate	P-Value
			Yes	No		
>20 years	80	61.5%	65	15	81.3%	0.328
< 20 years	50	38.5%	37	13	74.0%	

Table-II. Success Rate of MI with reference to location related factors

	Jaw of Insertion			Site of Insertion			Side of Insertion			Bone Quality				
	Maxilla	Mandible	P-Value	Buccal	Lingual	P-Value	Right	Left	P-Value	Q1	Q2	Q3	Q4	P-Value
	%	%		%	%		%	%		%	%	%	%	
Success	77.5%	79.7%	0.762	77.8%	100%	0.287	72.5%	85.2%	0.077	95.8%	94.4%	38.1%	23.1%	0.001*
Failure	22.5%	20.3%		22.2%	0.0%		27.5%	14.8%		4.2%	5.6%	51.9%	76.9%	

Table-III. Frequency and success rate of mini-implant with reference to age

Gender	Frequency (%)	Success		Success Rate	P-Value
		Yes	No		
Male	59 (45.4%)	41	18	69.5%	0.023*
Female	71 (54.6%)	61	10	85.9%	

Table-IV. Frequency and success rate of mini-implant with reference to gender

Malocclusion	Frequency (%)	Success		Success Rate	P-Value
		Yes	No		
Class I	44 (33.8%)	36	8	81.8%	0.120
Class II	72 (55.4%)	58	14	80.8%	
Class III	14 (10.8%)	8	6	57.1%	

Table-V. Frequency and success rate of mini-implant with reference to malocclusion

Oral Hygiene	Frequency (%)	Success		Success Rate	P-Value
		Yes	No		
Good	90 (69.2%)	73	17	81.1%	0.762
Poor	40 (30.8%)	29	11	72.5%	

Table-VI. Frequency and success rate of mini-implant with reference to oral hygiene

Jaw of Insertion	Frequency (%)	Success		Success Rate	P-Value
		Yes	No		
Maxilla	71 (54.6%)	55	16	77.5%	0.762
Mandible	59 (45.4%)	47	12	79.7%	

Table-VII. Frequency and success rate of mini-implant with reference to jaw of insertion

Site of Insertion	Frequency (%)	Success		Success Rate	P-Value
		Yes	No		
Buccal	126 (96.9%)	98	28	77.8%	0.287
Lingual	04 (3.1%)	04	0	100%	

Table-VIII. Frequency and success rate of mini-implant with reference to site of insertion

Side of Insertion	Frequency (%)	Success		Success Rate	P-Value
		Yes	No		
Right	69 (53.1%)	50	19	72.5%	0.077
Left	61 (46.9%)	52	09	85.2%	

Table-IX. Frequency and success rate of mini-implant with reference to side of insertion

Bone Quality	Frequency (%)	Success		Success Rate	P-Value
		Yes	No		
Q1	24 (18.5%)	23	01	95.8%	0.001*
Q2	72 (55.4%)	04	68	94.4%	
Q3	21 (16.2%)	08	13	38.1%	
Q4	13 (10.0%)	03	10	23.1%	

Table-X. Frequency and success rate of mini-implant with reference to bone quality

DISCUSSION

Temporary anchorage devices are used in orthodontic treatment where anchorage requirement is critical and difficult tooth movements are planned.[7] Orthodontic mini-implants are innovative and efficient anchorage devices. Orthodontic mini-implants are used for space closure, skeletal anchorage system, intrusion of anterior teeth, molar intrusion, molar protraction and distalization, correction of molar cross-bite and correction of open bite, but there are some associated problems like pain, root damage, soft tissue inflammation, mini-implant fracture and ulceration. Therefore, they must be applied with extreme caution. In this study, patient and location related factors were evaluated in the clinical success of mini-implant.[5]

For patient related factors, success rate in females (85.9%) was significantly higher than in males (69.5%), whereas according to a study done by Rasool et al[7] and Baik et al no difference was found in success rate of mini-implant.[16] In our study, patients were divided into two sub-groups; above 20-year group showed 81.3% success rate and below 20-year group showed 74.3% success rate with no significant differences, which is similar to the studies conducted by Lai et al[5] and Rasool et al.[7] However, a study conducted by Aly et al found significant difference between the two age groups.[14] Regarding malocclusion, the success rate in class III (57.1%) was lower than class I (81.8%) and class II (80.6%) malocclusion, however it was statistically insignificant. Lin et al[17] showed similar results. On the contrary, Beak et al[18] showed significant difference between class I, II and III malocclusions. The reason for this discrepancy related to Class III malocclusion could be a small sample size due to low prevalence in Pakistani population which was not enough to accurately depict success and failure.

In our study, oral hygiene did not significantly impact success rate of mini-implant similar to many studies conducted by Upadhyay et al and Lee et al.[19,20] A study by Aly et al and Jing et al showed oral hygiene to be a determinant factor in the success rate of mini-implant.[14,21] They concluded severity in peri-implantitis, pain and looseness of mini-implant in people with poor oral hygiene. In this research almost all the mini-implants were inserted in attached gingiva to prevent complications associated with insertion in non-keratinized mucosa.

For location-related factors, there was no significant difference among side of insertion which was similar to a study conducted by Lai et al and Beak et al.[5,18] As for site of insertion, no significant difference was found between them, however success rate on lingual side (100%) was higher than buccal side (77.8%). Furthermore, the sample size of lingual MI (7) was low, and all were successful, similar to a study conducted by Topouzelis et al and Shouicihi et al.[22,23] Both jaws showed similar success rate in this study that was supported by a study conducted by Shehab A. Aly in Egypt[14] and Song Yi Lin in Singapore.[17] On the contrary, a study conducted by Tai-Ting Lai in Taiwan[5] showed significant difference between upper and lower jaws and different sites of insertion. In terms of bone quality, success rate was highest in Q1 (95.8%), and it descended to Q4 (23.1%) with a significant difference between them. Bone quality is a very critical factor affecting the success of dental implants and showed similar results to a study conducted by Lai et al.[5] Sites with thick cortical bone, dense cancellous bone, plenty of available bone, and thin attached gingiva are ideal for mini-implant insertion, since they increase the chances of achieving proper primary stability, achieving and maintaining secondary stability, and preventing local inflammation. Thin

cortical bone and cancellous bone with very low density adversely affect the success of mini-implants.[24]

In the current study, only location and patient related factors were assessed, while implant related factors were kept constant. Other studies can be conducted to assess implant related and operator related factors for a thorough review. Nevertheless, mini-implants have a good success rate and offer versatile options in the domain of orthodontics.

CONCLUSION

Orthodontic mini-implants are very useful in orthodontic treatment, provided that favorable factors are involved to ensure their success. Bone quality and gender were significant factors, which impact the clinical performance of orthodontic mini-implants. Other patient-related and location-related factors did not significantly impact the success rate of orthodontic mini-implants. The potential factors highlighted in this study will help to guide the clinicians to optimize the success rate of mini-implants in orthodontic practice.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

No.	Author(s) Full Name	Contribution to the paper	Author(s) Signature
1	Faiza Malik	Analysis and interpretaion of data, Drafting and revising it critically, Final approval of the review of the published.	
2	Fiza Khan	Conception of design of the work, acquisition of data, checking the work.	
3	Sundas Ali	Analysis interpretation of data, drafting out revising it critically.	
4	Faiza Rana	Drafting the work and revising it critically.	
5	Hooria Haq	Drafting the work and revising it critically.	
6	Mazhar Hussain	Drafting the work and revising it critically.