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Survival analysis of temporary anchorage devices: A retrospective analysis in a Nigerian orthodontic patient population

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Abstract

OBJECTIVES: Temporary anchorage devices (TADs) are skeletal anchorage devices. They are minimally invasive and placed by the orthodontist to prevent unwanted tooth movement. This study evaluated the survival rate of orthodontic TADs at 6 months. This study also assessed the effect of age, gender, side, site, dental arch of placement, and length of the TADs on its survival rate.

MATERIALS AND METHODS: Ethical approval was obtained from the Health Research Ethics Committee of the hospital. The study sample comprised orthodontic patients who required the placement of TADs during treatment at a private dental facility in Lagos. Data for the study were obtained from the case files of the study subjects and included the subjects' age, gender, date of placement of the TADs, the site, side and arch of placement, the length of the TADs, and the survival rate of 6 months after placement.

RESULTS: We reviewed 90 placed TADs and observed a survival rate of 88.9%. Most TAD failures occurred in the first month of placement (p = 001). There was no observable statistically significant effect of all other variables assessed (age, gender, arch, site, side, or implant length) on the survival rate of the TADs.

CONCLUSIONS: The survival rate of TADs was high. Most TAD failures significantly occurred within one month of placement. There was no significant association between all other clinical variables and orthodontic mini-implant survival.

Keywords:

Anchorage, mini-implants, orthodontics, survival rate, TAD, temporary anchorage devices

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Introduction

Anchorage is important for a successful treatment outcome in orthodontics. Adequate anchorage must be employed to avoid unwanted tooth movement.[1] Graber defined anchorage as the nature and degree of resistance to displacement offered by an anatomic unit when used to affect tooth movement,[2] while Lewis simply defined it as the resistance to unwanted tooth movement.[3]

The sources of anchorage may be intraoral (teeth, alveolar bone, cortical bone, basal jaw bone, and musculature) or extraoral (occipital bone, palatal bone, frontal bone, mandibular symphysis, and back of the neck).[1] Absolute anchorage is sometimes desirable, but it is usually unattainable with traditional orthodontic mechanics. Skeletal anchorage offers absolute anchorage and ensures that forces applied to the teeth are completely transferred to the surrounding skeletal structures, bringing about the absolute anchorage.[4]

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Temporary anchorage devices (TADs) or mini-implants are skeletal anchorage devices, which are minimally invasive, and they do not require raising a flap and can be inserted by the orthodontist.[5] They have been proven to be effective and reliable with reported success rates ranging from 72.5% to 98.6%.[6-9]

Various factors, including patient's age, sex, gender, screw length and diameter, and site and side of insertion, have been widely researched by different studies to assess their contributions to survival rates of TADs, with conflicting results.[7-18] Evaluating the effect of the site of application on the survival of TADs, some previous studies observed that TADs inserted in the maxilla have higher success rates than those inserted in the mandible.[7,8,10,11] At variance, however, is the finding of Wu *et al*.[12] who reported a higher mini-implant survival rate in the mandible. The effect of factors such as age, gender, side, and length of TADs has also been assessed with conflicting findings.[7-18] A systematic review by Beltrami *et al*.[13] showed that more studies concluded that gender and length have no statistically significant effect on the survival rate of TADs.[13] Wu *et al*.[12] in a study in the Taiwan population reported no association between the length, type of TADs, age, and gender of the patient with the failure rate of the TAD. At variance with the aforementioned findings are the findings of Jan Hourfar *et al*.[10] who observed that the success rate of TADs has also been found to be affected by side of implantation where the left side was seen to have a higher success rate.[10] Morphological differences have been observed with diversity in race and ethnicity with very limited research on the current study in the African population.

Therefore, the purpose of this study was to evaluate the survival rate of TADs over a 6-month period in an orthodontic population. This study also assessed the effect of certain demographic and clinical variables such as age, gender, side, site, dental arch of placement, and length of the TADs on the survival rate.

Materials and Methods

This was a retrospective study. Ethical approval was obtained from the Hospital's Health Research Ethics Committee before the commencement of the study. The study sample comprised orthodontic patients who required the placement of TADs during treatment at a private dental facility from January 2018 and May 2022. A total of 63 patients who fulfilled the criteria were included in the study.

Data for the study were obtained from the case files of the study subjects and included the patients' age, gender, date of placement of the TADs, the site, side and arch of placement, its length, and the survival rate of 6 months after placement. A TAD was considered to have failed when there was mobility or complete dislodgement of the device.

Inclusion and Exclusion Criteria

Inclusion criteria

Subjects undergoing orthodontic treatment who required mini-implant placement as part of their treatment.

Exclusion criteria

Subjects with any craniofacial anomalies such as cleft lip and palate deformities.

History of systemic illnesses that may compromise patients' immunity, for example, diabetes mellitus, leukemia, and human immunodeficiency virus (HIV).

Patients on drugs that may compromise bone turnover, for example, bisphosphonates.

Sample size calculation

The sample size was calculated by conducting an a priori power analysis using the G Power software (latest version 3.1.9.7; http://www.gpower.hhu.de/)[19,20] to determine the required sample size for a one-tailed t-test to detect a difference between two independent means.

To calculate sample size n, in G Power the following parameters are needed: α, *Effect Size*, and *Power*.

n = the sample size, the number of subjects in the study.

α = the probability of rejecting a true null hypothesis. The threshold value is used to judge statistical significance.

Effect size = the relative magnitude of the effect.

Power = the probability of rejecting a false null hypothesis.

From the calculations in G Power, the sample size $n = 56$, where

$\alpha = 0.05$.

Effect size = 0.80.

Power $(1-\beta) = 0.90$.

The sample was increased by 10% to make up for possible/anticipated attrition. Hence, 56 + 5.6 = 61.6. The sample size was rounded up to 62.

TAD placement

A single operator placed all TADs. Before placement, local anesthesia was achieved. The researcher prepared the patients' mouths using 0.2% chlorhexidine for one minute before the procedure. The anchorage devices (Speed Dental Korea, diameter 1.6 mm) were subsequently placed in the site using the implant driver (Speed Dental Korea). Anchorage devices with lengths of 8 mm and 10 mm were randomly placed in the proposed site for the patient and loaded immediately. The TADs were reviewed 4-weekly during routine orthodontic follow-up. The researcher considered all mini-implants that demonstrated mobility or complete dislodgement as failed or unsuccessful.

Statistical analysis

Statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) software version 23. Descriptive analysis was carried out using frequency and proportion for categorical variables and mean and standard deviation for numeric variables. Categorical data were analyzed using Pearson's Chi-square test, Fisher's p, and Spearman's correlation test, where applicable, to test for the association; a preset significance level of $P < 0.05$ was adopted. The researcher presented the findings in frequency tables, cross-tabulations, bar charts, and pie charts.

Results

A total of 63 patients with a variety of malocclusions were recruited for the study with a male-to-female ratio of 1: 2 [Table 1]. The subjects' mean age was 28.01 years ± 11.503 with the highest percentage of subjects in the study within the age range of 11 to 20 [Figure 1]. A total of 90 TADs were placed with a success rate of 88.9% [Figure 2]. Of the 10 (11.1%) TADs that failed, eight (8.9%) of them failed within the first month, while the remaining two each failed at the 2^{nd} (1.1%) and 3^{rd} (1.1%) months, respectively [Table 2]. There was a significant association between the failure rate of the TADs and the duration of time (in months) since the placement of the anchorage devices (p-value = 0.001).

The researcher observed the highest failure rate in the 11 to 20 age group (15.6%), with the highest success rate occurring in patients within the 21 to 30 age group (100%) [Table 2]. A higher survival rate of the anchorage devices was seen in females (91.8%) compared with males (82.8%) in this study with no statistically significant association (p = 0.202) [Table 2].

Table 1: Descriptive statistics of demographic variables

TADs/demographic variables	Frequency	Percentage
Gender		
Female	61	67.8%
Male	29	32.2%
Length (mm)		
8 mm	70	77.8%
10 mm	20	22.2%
Side		
Left	42	46.7%
Right	48	53.3%
Arch		
Upper	38	42.2%
Lower	52	57.8%

An assessment of the association between the length of the TADs and failure rate revealed more failure with the 8 mm devices (14.3%) although statistically insignificant (p = 0.073) [Table 2]

In this study, devices were placed in either of three sites: buccal, palatal, and labial segments, with the majority in the palate [Figure 3]. There was a 100%

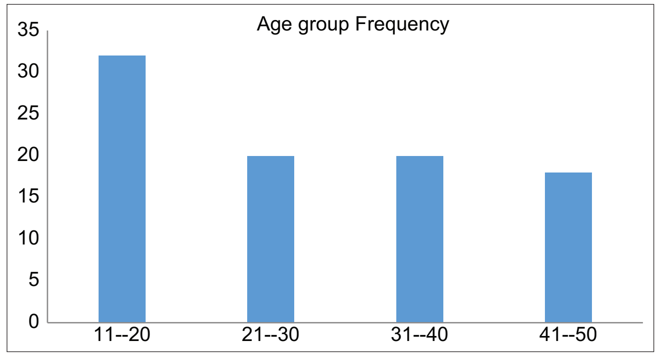

Figure 1: Age distribution of study participants

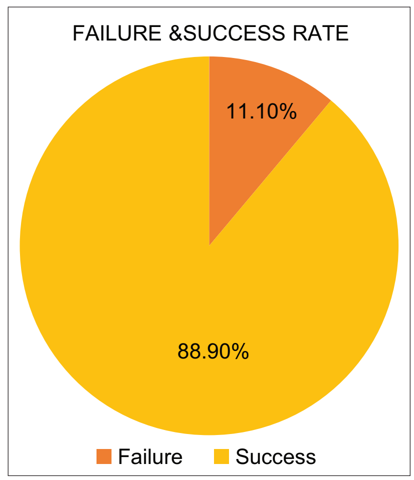

Figure 2: Survival analysis of the temporary anchorage devices in participants of this study

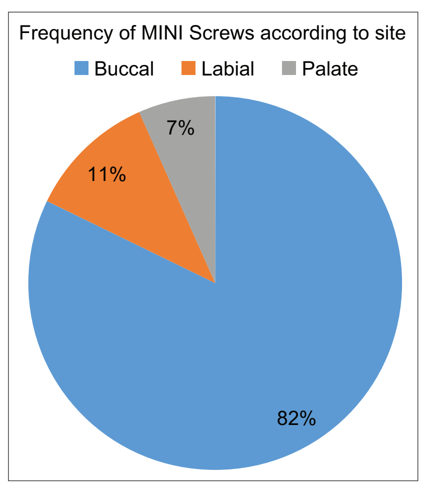

Figure 3: Site distribution of the temporary anchorage devices

Table 2: Effect of demographic variables on survival of temporary anchorage devices

Factor	Failure: No	Failure: Yes	Success rate	Failure rate	Fisher's *P*
Gender					
Female	56	5	91.8%	8.2%	
Male	24	5	82.8	17.2%	0.202
Total	80	10	88.9%	11.1%	
Age group					
11–20	27	5	84.4%	15.6%	
21–30	20	0	100%	0%	0.104
31–40	19	1	95%	5.0%	
41–50	14	4	77.8%	22.2%	
TAD length					
8 mm	60	10	85.7%	14.3%	
10 mm	20	0	100%	0%	0.073
Site					
Buccal	64	10	86.5%	13.5%	
Labial	10	0	100%	0%	0.296
Palate	6	0	100%	0%	
Side					
Left	38	4	90.5%	9.5%	
Right	42	6	87.5%	12.5%	0.654
Arch					
Mandible	33	5	86.8%	13.2%	
Maxilla	47	5	90.4%	9.6%	0.597
Duration of placement (months)	**Failure**		**Failure rate**		
1	8		8.9%		
2	1		1.1%		0.001
3	1		1.1%		
4 to 6	0		0%		

Millimeters (mm). *P*=0.05 (Fisher's p-exact)

survival rate of all the palatal and labial sites; hence, all device failures were observed in the upper and lower buccal segments. However, the association between the site of device placement and survival rate was statistically insignificant (p = 0.296) [Table 2]. In this study, the survival rate of TADs was more on the left side (90.5%) than on the right side (87.5%) with no statistical significance (p = 0.654), while concerning the arches, the anchorage devices placed in the maxilla had a higher success rate (90.4%) than those placed in the mandible (86.8%) also with no statistical significance (p = 0.597) [Table 2].

Discussion

A dependable anchorage source prevents unwanted tooth movement; therefore, anchorage control is very important in orthodontic treatment. Gaining absolute anchorage through TADs has recently grown in popularity among orthodontists because of its efficiency and simplicity.[12] Various studies have shown relatively high success rates for TADs,[6-9] which agrees with findings from our study with a success rate of 88.9% [Figure 2].

The present study observed a significant relationship between TAD failure and time. Over the 6-month observational period, all the failures that occurred (11.1%) did so within the first 3 months with 8.9% occurring in the first month [Table 2]. This finding is in tandem with a study carried out by Jeong *et al.*,[14] who also found that implant failure was highest in the first 4 to 5 weeks before loading and concluded that the stability of the anchorage device is acquired 12 to 16 weeks after insertion. This could be because bone resorption in the bone remodeling process is most active around 4 weeks after insertion in humans. The bone apposition is achieved 3 to 4 months after insertion;[14] hence, it is not surprising that most of the mini-implant failures occurred within the first 3 months of insertion. The fact that all anchorage devices in this study were loaded immediately may have a role to play in the time of failure and eventual survival of the implant. However, the impact of time of anchorage device loading on survival has shown conflicting results among previous investigators. Studies by Al-Sawai *et al.*[15] and Romanos *et al.*[16] showed that immediate loading of mini-implants had good stability and better survival. These reports are, however, contrary to the findings by Ramazanzadeh *et al.*,[17] whose study observed no significant differences in success rate between immediate loading and delayed loading.[17] Again, at variance with the previous studies is the report of Wu *et al.*[12] who reported higher failure rates of anchorage devices when loading time after insertion was less than 12 weeks in an Asian population.[14] Variations in findings may be attributed to racial differences, skill of operator, types of devices used, and the amount of force loaded on the anchorage devices. Future studies in this field may try to assess this aspect, so that a more definitive conclusion can be made as to whether these factors have significant roles to play in the success of TADs.

Regarding the site of TAD placement, the current study showed no statistically significant effect on the survival rate, although the maxilla showed a slightly higher survival rate (90.4%) [Table 2]. This finding agrees with the school of thought that the maxilla is a better site for anchorage device placement than the mandible.[13] In agreement with previous reports, this study similarly observed that mini-implants placed on the left side had a higher success rate than those placed on the right side.[8,12,18] This could be attributed to better hygiene on the left side of the dental arch by right-handed patients, who comprise most of the population.[21] Better hygiene could reduce inflammation around the anchorage devices.[8]

For patient-related factors such as age and gender, no statistical significance was found, with the highest success (100%) rate recorded in patients aged 21 to

30 years. This corroborates the findings by Motoyoshi *et al.*,[22] who reported a higher survival rate of TADs in the adult group compared with adolescents. Additionally, we observed a higher success rate of the mini-implants in females (91.8%) than in males (82.8%) [Table 2], which is contrary to what was found in the study carried out by Manni *et al*.[7] who reported a higher success rate in males. The females in the study by Manni *et al*.[7] were older than those in the present study, with an increased likelihood of osteoporotic changes. This may affect bone quality and compromise implant survival in these subjects. This study has many limitations. Primarily, the retrospective nature of the study limited the collection of certain data, which could have also affected the survival of the TADs. These include the oral hygiene of the patients, smoking history, amount of loading force, and time of loading the TADs. Thus, there is a need for future prospective studies in this field to assess the survival analysis of TADs and determine the effect of all the aforementioned parameters on their success rate.

Conclusion

The survival rate of TADs in this study was 88.9%. A majority of the mini-implant failure occurred within the first month with a significant association observed between mini-implant failure and time within the first month of placement. There was no significant association observed between age, gender, side, site, dental arch of placement, length of the TADs, and the survival rate of the orthodontic mini-implant survival.

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Conflicts of interest
There are no conflicts of interest.

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