Survival Analysis of Orthodontic Micro-Implants: A Retrospective Study on the Effects of Patient-Related Factors on Micro-Implant Success

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Abstract

Aim: The study aims to assess the impact of patient-related factors on the survival and success of orthodontic micro-implants.

Materials and methods: A total of 50 patients (27 females, 23 males; mean age, 32.2 ± 3.9 years) received 110 orthodontic micro-implants, which were self-tapping and tapered. The implants were placed in the buccal alveolar bone between the premolars and molars using a self-drilling technique under local anesthesia. Data analysis was done using SSPS software.

Results: The study cohort consisted of 50 patients, including 23 males and 27 females. The mean age was 29.3 ± 5.54 years for males and 32.2 ± 4.67 years for females, with an overall average of 30.87 ± 1.2 years. A total of 110 orthodontic micro-implants were analyzed, with 53 placed in male patients and 57 in female patients. Micro-implants that underwent immediate loading demonstrated a higher failure rate, while those classified as Type III in Kuroda's classification had the greatest risk of failure. However, cortical bone thickness and bone density did not significantly differ between successful and failed micro-implants.

Conclusion: The success of orthodontic micro-implants is not influenced by anteroposterior or vertical skeletal patterns.

Keywords: micro-implant, orthodontic, anteroposterior

Introduction

Anchorage is a crucial factor in orthodontic treatment, traditionally relying on teeth, extraoral, or intraoral appliances that often require patient compliance. Orthodontic mini-implants

(OMIs), also known as temporary anchorage devices (TADs), mini-implants, or mini-screws, offer an effective alternative by providing stable skeletal anchorage for complex tooth movements. Their versatility, minimal invasiveness, and favorable cost-benefit ratio make them valuable in managing challenging malocclusions, maxillary protraction, cleft expansion, and stabilization. By preventing unwanted tooth movement, OMIs help avoid orthognathic surgery and allow treatment in patients with insufficient dental anchorage or poor compliance. They also enhance orthopedic growth modification and camouflage treatments for patients not eligible for surgical intervention.[1,2,3,4]

Successful use of micro-implants depends on atraumatic surgical techniques, biocompatible materials, and patient cooperation, as pain perception and surgical procedures can influence acceptance. Many orthodontists hesitate to use OMIs due to unfamiliarity with the surgical process or fear of failure. However, acquiring these skills is essential to integrating micro-implants into clinical practice. By understanding the different types of OMIs, their applications, and potential complications, orthodontists can expand their treatment options and improve outcomes for patients requiring enhanced anchorage control. [5,6]

In our study we aim to assess the impact of patient-related factors on the survival and success of orthodontic micro-implants.

Materials and methods

A total of 50 patients (27 females, 23 males; mean age, 32.2 ± 3.9 years) received 110 orthodontic micro-implants, which were self-tapping and tapered. The implants were placed in the buccal alveolar bone between the premolars and molars using a self-drilling technique under local anesthesia. Some micro-implants were loaded immediately, while others were loaded after 2–8 weeks. Failures, defined by inflammation and mobility, led to removal and replantation after 2–3 months.

Cortical bone thickness and alveolar bone density were evaluated using CBCT to assess their impact on implant survival. Bone densities were measured in Hounsfield units and Root proximity was assessed through intraoral radiographs using Kuroda et al.'s classification: Type I (no contact), Type II (apex touching lamina dura), and Type III (screw body overlying lamina dura). Data analysis was done using SSPS software.

Results

The study cohort consisted of 50 patients, including 23 males and 27 females. The mean age of male patients was 29.3 ± 5.54 years, while that of female patients was 32.2 ± 4.67 years, resulting in an overall mean age of 30.87 ± 1.2 years. A total of 110 orthodontic micro-implants were evaluated, with 53 placed in male patients and 57 in female patients.(Table 1)

Table 1: Sample characteristics of the study cohort (n = 50).

	Male	Female	Total
Number of patients (n)	23	27	50
Age (years, mean ± SD)	29.3 ± 5.54	32.2 ± 4.67	30.87± 1.2
Number of micro-implants (n)	53	57	110
Anteroposterior skeletal pattern [1] (n)			
Class I	11	14	25
Class II	8	6	14
Class III	4	7	11
Vertical skeletal pattern [2] (*n*)			
Normal	15	17	32
Short	3	3	6
Long	5	7	12

1 Class I, 0° ≤ ANB < 4°; Class II, ANB ≥ 4°; Class III, ANB < 0°. 2 Normal, 31° ≤ SN-GoGn < 39°; Short, SN-GoGn < 31°; Long: SN-GoGn ≥ 39°. SD: standard deviation.

Also, Micro-implants subjected to immediate loading exhibited a higher failure rate, while those classified as Type III according to Kuroda's classification had the highest likelihood of failure. In contrast, cortical bone thickness and bone density showed no significant differences between successful and failed micro-implants.

Discussion

Orthodontic micro-implants, also known as temporary anchorage devices (TADs), have become a valuable tool in modern orthodontics, providing reliable skeletal anchorage for various tooth movements. Their success depends on multiple factors, including patient characteristics, anatomical considerations, surgical techniques, and biomechanical forces. Survival analysis of micro-implants helps identify key determinants influencing their longevity and effectiveness in clinical practice.[7,8] By evaluating factors such as bone density, root proximity, loading protocols, and skeletal patterns, researchers aim to enhance treatment outcomes and improve the predictability of micro-implant-supported orthodontic therapies.

Our study included a cohort of 50 patients, comprising 23 males and 27 females. The mean age was 29.3 ± 5.54 years for males and 32.2 ± 4.67 years for females, with an overall average of 30.87 ± 1.2 years. A total of 110 orthodontic micro-implants were analyzed, with 53 placed in male patients and 57 in female patients.

Micro-implants that underwent immediate loading demonstrated a higher failure rate, while those classified as Type III in Kuroda's classification had the greatest risk of failure. However, cortical bone thickness and bone density did not significantly differ between successful and failed micro-implants.

In the study by Lee JK et al.[9] aimed to evaluate the effects of patient-related factors, including anteroposterior and vertical skeletal patterns and alveolar bone density, on the success of orthodontic micro-implants. A total of 404 micro-implants (1.6 mm diameter, 6 mm length) were examined in 164 patients (127 women, 37 men; mean age, 23.6 ± 5.8 years). Cortical bone thickness and alveolar bone density were measured using cone-beam computed tomography (CBCT) to assess their impact on micro-implant survival. Anteroposterior and vertical facial patterns were considered independent variables, while additional factors such as age, sex, implantation side and site, root proximity, and type of loading (immediate vs. delayed) were also analyzed. Marginal survival analysis, assessing the time from implant placement to failure or treatment completion, revealed that 347 (85.9%) of the 404 micro-implants were successful, with a mean loading time of 12.4 ± 4.3 months. The analysis indicated that anteroposterior and vertical skeletal patterns had no significant effect on micro-implant failure risk. However, cortical bone density, root proximity, and reimplantation at the same site significantly influenced the micro-implant's loading time. The findings suggested that while skeletal patterns did not impact micro-implant success, cortical bone density might play a crucial role in their stability.

The study by Lee MY et al.[10] aimed to evaluate the effect of bone densities on the success rate of orthodontic micro-implants using cone-beam computed tomography (CBCT) images. A total of 127 micro-implants placed in the maxillary buccal alveolar bone of 71 patients (53 females, 18 males; mean age, 19.2 years) with malocclusion were examined. Cortical, cancellous, and total bone densities were measured using Simplant Pro 2011 software, and their correlations with micro-implant success rates were analyzed. The overall success rate was 85.0% (108 of 127), with no significant associations found between success and factors such as sex, age, or placement side ($P > 0.05$). The results showed that cortical bone density increased apically (at 3, 5, and 7 mm from the alveolar crest), while cancellous bone density decreased. Success rates significantly improved with higher cancellous and total bone densities ($P < 0.01$), whereas cortical bone density did not have a significant effect on micro-implant success ($P > 0.05$). These findings suggested that cancellous and total bone densities played a crucial role in the stability of orthodontic micro-implants, while cortical bone density had minimal influence.

The study by Brij D et al.[11] aimed to comprehensively examine and compile existing research on orthodontic factors influencing mini-implant success. The review highlighted various orthodontic factors impacting success rates, with particular emphasis on biomechanical aspects such as loading conditions and orthodontic forces that influence mini-implant stability. The synthesis of existing evidence provided valuable insights into the multifaceted nature of these variables, underscoring the importance of a holistic approach that integrates patient-specific factors, precise surgical techniques, and biomechanical principles to improve the predictability and longevity of mini-implant-supported orthodontic treatments. The findings emphasized that understanding the etiological factors contributing to mini-implant success is essential for optimizing orthodontic therapy, and recognizing the causes of mini-implant failure could help clinicians refine their treatment strategies and improve clinical outcomes.

One constraint of our research was the limited sample size, which could influence the applicability of the results. An expanded cohort would enhance statistical power and yield a deeper comprehension of the elements affecting the success and failure of micro-implants. Subsequent investigations involving a larger participant group may assist in corroborating these findings and provide more thorough insights into how loading protocols, bone density, and root proximity affect the stability of micro-implants.

Conclusion

The success of orthodontic micro-implants is not influenced by anteroposterior or vertical skeletal patterns.

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