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Evaluation of the Survival Rate of Maxillary Minis in the Inter-Radicular Position

—Retrospective Study of 163 Clinical Cases

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Abstract

Introduction: The contribution of bone anchorage to orthodontic practice is now a matter of course, and effectiveness no longer needs to be demonstrated. Their comfortable success rate could be further improved by a better understanding of failures. The aim of this study was to evaluate the 1-year survival rate of minivis placed in the maxilla for distalizing mechanics. **Materials and Methods:** Our study involved 326 screws placed in 163 patients. The parameters studied were long-term stability factors, at least one year after mini-screw insertion. This was a retrospective study of patients attending an orthodontic practice in Toulouse. The aim of the study was to analyse the 1-year survival rate of miniscrews placed in the maxilla for orthodontic treatment with molar distalization mechanics. All patients were treated by the same practitioner, an exclusive orthodontist. Patients were informed about the study, and their consent to the use of their clinical records was obtained. The treatment plan included a maxillary recession mechanism assisted by a pair of bilateral minivis. **Results:** The results suggest that the angulation at the time of placement is a determining factor in the stability factors linked to the placement technique. We note that a more vertical placement of 6˚ on attached gingiva increases the survival rate of minivis by around 10%, bringing the loss rate below 5%. With regard to host-related factors, indicators of vertical facial typology were found to be the factors with the greatest influence on the long-term stability of minis. **Conclusion.** There is certainly a need for further research into bone density, which could not be assessed in this study.

Keywords

Survival Analysis, Orthodontics, Mini-Implants

1. Introduction

Orthodontic anchorage has long represented a major challenge in the conduct of treatment, particularly in the case of tooth movements requiring maximum stability. The introduction of orthodontic mini-screws, revolutionised orthodontic mechanics by providing a reliable, minimally invasive and easily removable skeletal anchorage. Historically, the first bone anchorage concepts date back to the 1980s, but it was not until the early 2000s that the use of mini-screws became widespread, thanks in particular to the work of Asian researchers who systematised their use in clinics [1]. Since their introduction exactly in 2002, mini screws haven improved orthodontics by providing reliable temporary bone anchorage. They are a reliable alternative to conventional anchors, and help to optimise and stabilise orthodontic movements.

Furthermore, according to Papadopoulos *et al.* [1], the use of minivis reduces the undesirable effects associated with loss of anchorage, and offers better biomechanical control and greater precision in tooth movement. Compared with conventional anchors, especially extra-oral anchors, minivis do not require rigorous adherence on the part of the patient, which consequently improves the clinical success [2]. With the reliability of anchorage offered by minivis, Choi *et al.* have found that translational and egressive dental displacements are managed more effectively [3]. Several authors have shown that anchorage stability contributes to a reduction in treatment time [4]. Despite their effectiveness, minivis can be prone to loss of anchorage, compromising the success of orthodontic treatment. According to [5], loss of anchorage can lead to changes in the direction of tooth movement and, therefore, a significant increase in treatment time [6]. Loss of anchorage may also be associated with complications such as soft tissue damage, local bone resorption or interference with adjacent anatomical structures [7], and the need to replace a dislodged miniscus or modify the treatment mechanics may generate additional costs for the patient and the practitioner [8]. However, their loss rate remains variable. According to several studies, the failure rate varies from 0.1% to 20%. Several factors may be to blame. This variability can be explained by a multitude of factors: patient-related parameters (bone quality, hygiene, age), implantation site (cortical vs cancellous), surgical protocol, and the characteristics of the mini-screw itself (length, diameter, surface, material). In addition, biomechanical factors, such as the moment of load application or the magnitude of orthodontic forces, also influence the primary and secondary stability of these devices.

The aim of this study was to evaluate the 1-year survival rate of maxillary miniscrews placed for distalising mechanics.

2. Materials and Methods

This was a retrospective study of patients attending an orthodontic practice in Toulouse. All patients were treated by the same practitioner, an exclusive orthodontist. Patients were informed about the study and their consent to the use of

their clinical records was obtained. The treatment plan included a maxillary recession mechanism assisted by a pair of bilateral minivis. All the minivises were fitted by the same orthodontist using a perfectly codified surgical protocol. The screws were only inserted on the same day as the maxillary multi-rings. The miniscrews were inserted without a flap, without pre-drilling, in keratinised gingiva so that they could be used classically in a transgingival manner. The site is chosen according to the anchorage requirements, the type of movement, the desired mechanics and the local anatomical conditions (in particular the inter-radicular space, root anatomy and sinus proximity). They are inserted mesially into the first molar or mesially into the second premolar. Symmetrical placement is preferred and in line with therapeutic objectives. Manual screwing is carried out exclusively using a medium-sized bell shaft for hexagonal heads (ref.: cch4—GlobalD) mounted on a conventional screwdriver handle (ref.: mtm—GlobalD). Screws are systematically installed before the fasteners are fitted so as not to alter the operating conditions. After external and internal antisepsis of the mouth with a solution of Povidone-iodine (Betadine® Yellow), a local anaesthetic is administered submucosally with Articaine-Adrenaline 1/200,000 (Septanest®). The marks of the roots of the adjacent teeth are taken with the probe. The head of the screw is then placed in the Allen key to avoid an undesirable screw thread. The tip of the screw is initially drilled through the gum at 90˚ to the cortical bone. Once screwing has begun, the orthodontist vertically aligns the mini-screw, which should be at an oblique or vertical angle to the alveolar process. The initial stability of the screw is then checked using a dental pre-calibrator. The angulation of the axes of the miniscrews in relation to the occlusal plane was then calculated using the same procedure by placing hexagonal socket spanners with a long axis (50 mm) on the heads of the right and left miniscrews.

After an articulator fork has been fitted, it is held in occlusion by the patient by biting; the stem is centred on the inter-incisal middle, and lies sagittally in line with the plane of occlusion. A photographic shot focused on the key bells and in the aiming axis coincides with the axis of the rod, so that it is exactly in the occlusion plane. The camera used was a Nikon DX80 with a ring flash set to manual medium focal length. AdobeR PhotoshopR CC version 14.0 × 32 was used to process the photo and measure the angles of the minivis in relation to the occlusal plane. Immediately after loading, the arch is fitted with a brace and the distal screw mechanics are inserted. The brackets used are self-ligating in metal or ceramic (autofix or orthoclear American Orthodontics). Square NiTi archwires, springs and accessories are standardised (AO). The distal technique used to treat the patients was an indirect mechanical technique that achieves pure distalization of the molars by combining a vertical component on the molars. This technique was used on the entire sample during the initial phase and can be continued or supplemented by other types of direct or indirect mechanical assembly.

For each patient, we took into account the following information: Last name, First name, date of birth, sex, age, date of screw placement, location of mini-screws

on the arch. Prior to placement, patients underwent the standard procedures: clinical examination, exo- and endobuccal intra- and inter-arch photographs, impressions, radiological examination: X-ray panoramic and profile teleradiography. All radiographs were taken using the same generator (Tx2-Planmecca-Norway) and cephalometrics were performed by the same operator. A review of the file and clinical record, together with an in-depth cephalometric analysis, is carried out to determine whether candidates meet the following inclusion criteria:

Inclusion criteria:

- Patients under the age of 18 with adult teeth.
- Patients presenting an indication for maxillary sectorial recoil treatment: these mainly correspond to cases with class II or class I inter-arch relationships with mandibular crowding or biproalveolism.
- The same practitioner fitted the braces.
- No additional mini-screws are used in the upper arch.
- Treatment begins on the maxillary arch.

Non-inclusion criteria:

- Refusal to take part in the study.
- Incomplete file or non-compliant X-rays.

Exclusion criteria:

- Loss of teeth.
- Patient was lost to follow-up for a year.
- Mini-screw removed for external causes: pathology, trauma.

Data collection was based on information from the management software. The clinical form was followed up 365 days after insertion.

On the day of collection, the following clinical and paraclinical data were collected:

- The angle of inclination of the mini-screws in relation to the occlusal plane.
- Bone maturity: Maxillary bone maturity is graded from 1 to 5.

Bone maturation was assessed using the cervical maturation method (CVM), based on analysis of the cervical vertebrae. This assessment was used to classify patients into 5 maxillary bone maturation stages (levels 1 to 5).

- Facial typology:

The facial morphology of the patients was characterised by several cephalometric parameters:

- Angulation of the mandibular plane in relation to SN.
- Anterior facial height.
- Posterior facial height from Tweed analysis.
- Total facial height.
- Ratio of posterior facial height to anterior facial height (HFA/HFT).
- Ratio of the lower face to the total face.
- Anterior-posterior offset:

Anteroposterior skeletal misalignment was assessed using the following cephalometric measurements: SNA, SNB and ANB.

In the event of screw loss, the following points were noted.

- the date of installation of the minvis,
- the date of the first failure,
- the number of days between installation and the first loss of the screw,
- the side involved, right, left or both.

The data were analysed using SSPS software to identify any associations between miniscule loss and parameters of bone maturation, facial typology and skeletal shift. Survival analysis was performed to assess the rate of miniscule retention as a function of time and identified risk factors. Quantitative variables are presented as mean ± standard deviation. Quantitative variables were compared between the two groups using the Mann-Whitney test. Qualitative variables are expressed as percentages and were compared using a Chi^2 test. The significance threshold was considered to be 5%.

3. Results

A total of 326 minivis from 163 patient files were analysed. The mean age was 13.1 ± 1.4 years. Regarding gender, 78 (47.85%) patients were male and 85 (52.15%) female. The most rapid loss occurred at 40 days, with a mean survival time of 322.78 days ± 7.25. The following Table 1 describes the sample according to the quanAtaAve variables for the full sample. Clinically, we have an average subject aged 13, normodivergent, in facial equilibrium, presenting with a class 2 skeletal due to mandibular retrognathia. Regarding the study variable, the mostrapid loss occurred at 40 days.

According to the angulation of the minivis in relation to the occlusal plane, the patient files were classified into 2 categories. Group 1 minivis were placed with an angulation less than or equal to 50˚ and Group 2 minivis were placed with an angulation greater than 50˚. Group 1 comprised 78 patients, and Group 2 comprised 85 patients. In Group 1, the number of minivises was n = 156 with 21 losses, *i.e.*, a loss rate at one year of 13.4%. In Group 2, the number of minivies was n = 170 with 8 losses, giving a one-year loss rate of 4.7%. The difference was not statistically significant, P = 0.06. Parameters related to facial typology showed that in both groups, it was hypodivergence measured by PMd/SN that increased the risk of loss ($p < 0.03$). A difference of 1.9˚ in the direction of hypodivergence significantly affected the survival of mini screw at 356 days ($p < 0.03$). There was no observable difference between the anterior facial ratios of Group 1 (HFA = 40.6 ± 6.1); Group 2 (HFA = 31.5 ± 5.9) and posterior Group 1 (HFP = 30.7 ± 3.4); Group 2 (HFP = 31.7 ± 5.9), or between the total facial height of Group 1 (HFT = 75.8 ± 5.7) and Group 2 (HFT = 82.6 ± 15.5). The posterior-anterior index for Group 1 HFP/HFA = 0.75 ± 0.07 and respectively for Group 2 = 0.71 ± 0.08 shows a difference between the two groups ($p < 0.02$). The higher the index, the more horizontal the direction of growth and the more vulnerable the screws appear to be to loss. With regard to lateralization, the right side was significantly less resistant ($t < 0.0045$) in Group 2. The more or less posterior position was not a factor in the

long-term performance of minivis in both groups.

Table 1. Table of quantitative variables: survival time (days), age (year) and cephalometric data.

	N	Min	Max	Mean	SD
MNV days	163	40.00	365.00	332.78	7.253
Age	163	9.90	17.81	13.11	0.106
PMSN	162	16.00	48.00	30.59	0.476
HFA	163	28.00	70.00	42.60	0.524
HFP	163	22.00	55.00	31.21	0.382
HFP/HFA	163	0.53	0.91	0.73	0.006
CVM	162	1.00	4.00	2.72	0.071
HFT	163	51.00	132.00	79.33	0.964
SNA	163	72.00	95.00	81.70	0.330
SNB	163	68.00	88.00	76.67	0.315
ANB	162	0.00	10.00	5.03	0.162
HFA/HFT	163	0.49	0.63	0.54	0.002

4. Discussion

Although this study showed interesting clinical results, it does have some limitations. The retrospective nature of the study meant that it was only possible to obtain an average angulation per group, and no precise measurement minivis by minivis was possible a posterio. Bone maturation was assessed using the cervical maturation method (CVM), based on analysis of the cervical vertebrae. Despite being recognised as a key success factor [9], bone density at the insertion site could not be accurately assessed. Reliable measurements could be made using CBCT data. The sample size of 163 patients was relatively small. The number of losses observed, particularly in Group 2, reduces the power of the analyses, particularly for exploring laterality or the mesial 5/mesial 6 difference. Clinical loss is the only criterion for judging the minivis. Other parameters, such as mobility or tissue response around the minivis, could be analysed in order to assess long-term stability in more detail. In most studies, the monitoring period is between 60 and 120 days, which corresponds to the initial loading phase [10]. In this study, a monitoring period of 365 days was chosen. This period allows for late failures linked to biological phenomena or progressive mechanical degradation. This methodological choice offers a more realistic view of clinical stability, in line with recent recommendations calling for longer observation periods [10]. However, despite the limitations, the results of this study show high survival rates for orthodontic minivises, with a statistically significant difference between the two groups studied. The group with a more vertical angulation at placement had significantly higher success rates (95.3%) than the group with a more oblique angulation (86.6%). These

results corroborate recent findings that angulation close to perpendicular to the bone cortex optimises the distribution of mechanical loads and improves long-term stability [11]-[13]. The length of follow-up has a direct influence on the interpretation of the results. The systematic search for verticality in the position of the minivis can lead to contact or even damage to the roots. Papageorgiou *et al.* [14] recommend an angulation of between 60˚ and 70˚ in relation to the bone surface. This range minimises the risk and provides satisfactory primary stability. However, some studies recommend that more vertical angulations (85˚ to 90˚) promote better stability and a reduction in micromovements under load [15]. The results of this study, although limited by the lack of systematic measurement of the actual angulation of each screw, tend to confirm this beneficial effect of a more vertical insertion. Depending on the side and site of insertion, the results of this study did not reveal any significant difference between minivis placed on the right or left, or between mesial 5 and mesial 6 sites. This result differs from some studies showing greater fragility of right-sided minivises, attributed to more difficult hygiene in right-handed patients [11]. In addition, a favourable trend has been noted in posterior minis, possibly linked to better bone density in the posterior sectors, as reported by Lee *et al.* [13]. Patient-related parameters, in particular oral hygiene and gum condition, were not taken into account in detail in this study. However, in the context of a patient population followed in private practice, these factors are often controlled upstream through rigorous selection and specific education. Nevertheless, the literature highlights their importance, with a clear association between poor hygiene and the risk of losing minivis [16]. Despite their proven effectiveness, there are still a number of avenues to explore in order to optimise the use of orthodontic mini-screws. Various types of study can be carried out, including longitudinal studies on long-term stability using 3D models to better analyse bone quality, and personalised approaches using artificial intelligence.

5. Conclusion

This study highlights the influence of the insertion angulation of orthodontic minivises on their survival rate at 12 months. Minivises inserted with a more vertical angulation showed significantly higher success rates, suggesting that an orientation close to perpendicular to the bone cortex could improve primary stability and resistance to the mechanical stresses applied during the orthodontic retraction phases.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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