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Resolution of lower second molar impaction through miniscrew-supported biomechanics: A proposal for a simplified classification

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Abbreviations
CBCT, Cone-beam computed tomography
TADs, temporary anchorage devices
MSOPA, lMiniscrew-Supported Orthodontic Pseudo-Ankylosis

Summary

Two case reports are presented showing how the strategic use of skeletal anchorage via orthodontic miniscrews manages to solve the complex problems of orthodontic disimpaction of second mandibular molars with excellent anchorage control and reduction of the adverse effects common to the use of conventional methods. The temporary anchorage device (TAD)-mediated biomechanics used can be categorized as both "pulling from the distal side'' and "pushing from the mesial side'' techniques in which both direct and indirect anchorage mechanics were employed. Each of these mechanics has its advantages and disadvantages, which must be weighed and considered on a case-by-case basis. Based on the force application side and the type of anchorage, a simplified classification of TADs supported biomechanics for the recovery of fully or partially impacted second molars is proposed.

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Introduction

The introduction of orthodontic temporary anchorage devices (TADs) has allowed simplified and ergonomic management of orthodontic anchorage [1]. The aim of orthodontic anchorage is to minimize unwanted dental reactions [2], bearing in mind that every action has an equal and opposite action [3]. Although dental anchorage can be well managed, it can never be absolute, only partial [1], which is why skeletal anchorage systems like TADs are often preferable today.

Nowadays, miniscrew TADs can be used in a wide range of clinical applications, to bear both orthodontic and orthopaedic forces [4]. Anatomical studies of the various insertion sites, including palatal, inter-radicular and extra-radicular sites, now allow the execution of complex movements with optimal anchorage control [5,6]. For example, bone-borne distalizing appliances and bone-borne rapid palatal expanders do not cause the dental side effects associated with the use of tooth-borne versions, specifically loss of anterior anchorage [7] and vestibularization of the lateral and posterior sectors [8].

Insertion of TADs may be classified as follows on the basis of how they are positioned:

Guided insertion of TADs, which are characterized by an internal screw connection system that ensures the head of the orthodontic miniscrew is fixed securely to the bone-borne appliance [9]. Their insertion need cone-beam computed tomography (CBCT) investigation with a subsequent full customized digital planning. Moreover, they are inserted through a computer-aided design/computer-aided manufacturing (CAD/CAM) surgical guide.

Free-hand insertion of TADs, which do not have an internal connection system to allow connection with a bone-borne or tooth–bone-borne appliance [10]. Usually, neither CBCT investigation nor digital planning are necessary and these miniscrews are manually inserted by the operator, on the basis of general anatomical bone mapping [5] and according to operator's skills.

Among the many clinical applications of free-hand insertion TADs described in literature, the orthodontic recovery of impacted lower second molar is one of them [10–13].

Second molar impaction is a severe although not frequent pathological condition (0.05–3%) [14–17]. Indeed, according to Bondemark, eruption issues are seen in around 2.3% of all cases; this can be broken down into 1.5% of cases of ectopic eruption (second molar impaction on the distal surface of the first molar), 0.6% of primary retention (blocking of the eruptive process without a physical cause) and only 0.2% impaction (physical presence of an obstacle to eruption) [18].

The aetiology of these conditions involves multiple factors, such as crowding in the posterior sector increased [16], distance between first and second molar, extraction and premature loss of the adjacent first molar [19], early eruption of the third molar [20], abnormal inclination of the second molar bud [21] and non-extraction orthodontic therapy with maintenance of leeway space for crowding resolution [22]. In addition, Vedtofte et al. reported that this pathological condition was associated with certain facial features, specifically Class II skeletal relationship due to micromandibulia, with a reduced gonial angle and mesialization of the mandibular dentoalveolar component, as well as some dental abnormalities such as root deflection, invagination and taurodontism [23].

Despite its low incidence, if left untreated, second molar impaction may have significant clinical implications. Hence, its early diagnosis and recovery, whenever possible, is recommended and desirable [18,24]. While this was possible with traditional orthodontics, it involved either the inevitable loss of anchorage on neighbouring teeth, or the use of bulky orthodontic equipment extending across a large number of teeth in order to create good dental anchorage and to dissipate collateral forces [20–25]. However, the introduction of direct TADs has made it possible to both reduce the size of the orthodontic appliances used [10], as well as to speed up treatment time, to minimize the risk of anchorage loss and to increase the predictability of programmed movements [11].

The aim of this article is to present two case reports in which the use of orthodontic miniscrews, with both direct and indirect anchorage, and appropriate biomechanics enabled the recovery of partially or fully impacted lower second molars both effectively and efficiently. A further aim is to propose a simplified rational classification of orthodontic miniscrew mechanics in such cases.

Case report 1

Diagnosis and aetiology

The first clinical case was characterized by partial horizontal osteo-mucosal impaction of both lower second molars in a female patient of 16 years of age who had undergone previous orthodontic treatment and lower third molars extraction. At the intra-oral level, the distal portion of the dental crown of both impacted teeth was clinically accessible (*figure 1*), although on

FIGURE 1

Pre-treatment occlusal intra-oral photo of case 1 showing the two partially impacted lower molars and orthodontic splinting (B), with the degree of impaction of teeth 47 (A) and 37 (C)

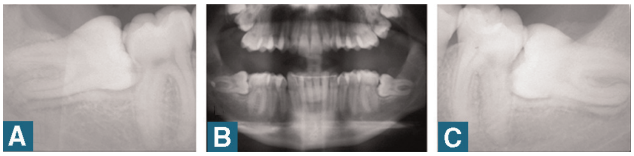

FIGURE 2
Pre-treatment panoramic radiograph (B) and peripical x-rays of teeth 47 (A) and 37 (C)

x-ray investigation they appeared positioned perpendicular to the lower first molars; moreover, tooth 37 was more deeply impacted (*figure 2*).

Treatment objectives

The treatment objectives claimed by patient and her parents are the resolution of posterior mandibular condition characterized by both lower second molars, that were both impacted despite the patient having received a previous orthodontic treatment.

Treatment alternatives

Having discussed the diagnosis with both patient and parents, various treatment options were proposed. The first of these was surgical extraction of the second molars on both sides, followed later by implant rehabilitation around the age of 19–21; this treatment option was categorically rejected by the patient, both for financial reasons and due to its invasiveness. Consequently, they also rejected the second treatment option proposed, namely surgical uprighting of both lower second molars. As this may have in any case have involved complications such as ankylosis, external apical resorption, loss of vitality and future loss of the affected tooth [26], the patient expressed the desire to undergo a conservative treatment even if this involved the fitting of a new orthodontic appliance, if necessary. So, the patient and her parents opted for the orthodontic recovery of both impacted elements using skeletal anchorage.

Treatment progress

Due to the severity of the impaction, a system was devised to exploit both a pushing force from the mesial side [11], i.e., the so-called dista-screw system [27], and a pulling force from the distal side [11].

The dista-screw system was created using two standard Quattro® PSM 1.5 mm × 9 mm miniscrews (PSM Medical Solutions, Gunningen, Germany) on both sides; these feature a head with 0.022 × 0.028-inch slot and a round 1.5-mm hole passing through the neck (*figure 3*). The TADs were inserted in an inter-radicular position between the lower first and second premolars, and two direct tubes (GC™ Orthodontics Europe GmbH, Breckerfeld, Germany) were positioned at the level of the clinical crown of the lower second molars. Flowable composite (Gradia, GC ™ Orthodontics Europe GmbH, Harkortstraße, Breckerfeld, Deu) was used to block both the mesial end of the hole of TADs and the distal extremity of the vestibular tube, and the system was activated with a compressed thermal 0.018-inch NiTi sectional archwire; this was covered with a plastic sleeve to both increase patient comfort and prevent decubitus at the fornix. The sectional archwire was about 1.5–1.8 times the length of the distance between the miniscrew head and the mesial entrance of the tube. This system was designed to exploit the superelastic properties of the archwire, exerting a force acting to upright the impacted teeth via distal inclination and extrusion. In this moment, no three-dimensional control of

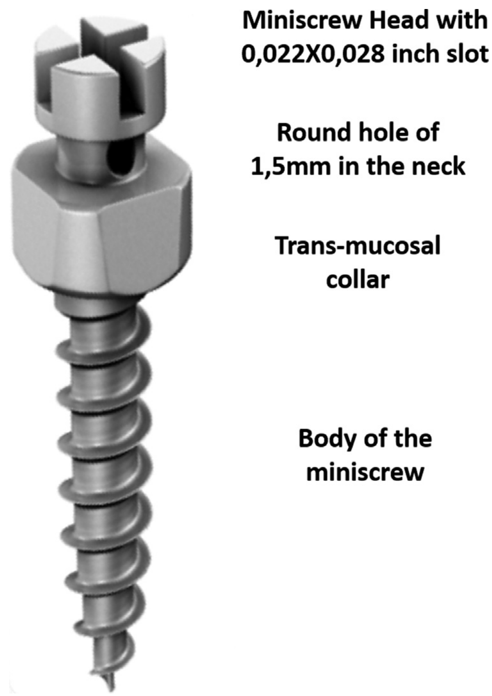

FIGURE 3
Structure of the standard PSM quattro miniscrew (1.5 mm × 9 mm)

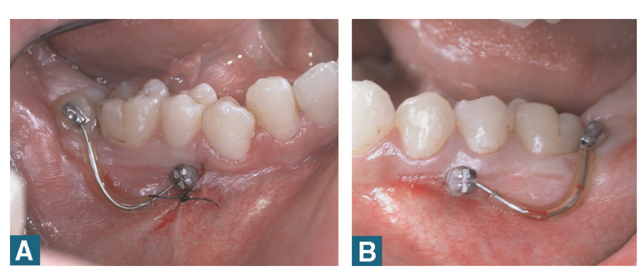

FIGURE 4
Dista-screw system positioned on teeth 47 (A) and 37 (B)

FIGURE 5

Occlusal photo showing the two orthodontic techniques in contemporaneous use (B). Particular of pulling from distal side mechanics using two inter-radicular miniscrews in both side (A, C). Orthodontic forces are achieved through the use of elastic chains stretched between the metal buttons positioned on the impacted teeth and the head of the miniscrews

teeth was sought since the aim was to obtain an uncontrolled distal movement to disimpact them as fast as possible (*figure 4*). Given the extreme complexity of both impactions, and to increase the effectiveness of the above-described mechanics, two miniscrews were also inserted into retromolar sites (on the right a 1.8 mm × 10 mm Ortho Implant miniscrew, IMTEC Corp, Ardmore, USA; while on the left a 1.6 × 10 mm Quattro® PSM Mini BH, PSM Medical Solutions, Gunningen, Germany) and were used to apply direct force in a distal direction via two elastic chains attached to two metal buttons bonded on the occlusal surface of the impacted lower second molars (*figure 5*). *figure 5* also provides an overview of the technique described above, combining the dista-screw system [27], with pulling from the distal side mechanics (*Figure 5*B) [11]. The positioning of the left button required a small incision of the gum to further uncover the coronal surface of tooth 37 (*figure 5*C).

The patient was checked monthly to reactivate orthodontic forces and renew the force exerted by the elastic chains. After just 4 months of active therapy, total disimpaction of tooth 47 had been achieved, despite the early loss of the Ortho Implant miniscrew, although tooth 37 had been only partially disimpacted. Moreover, the use of direct forces exerted on miniscrews, miniscrew on the right side was affected by unwanted mesial migration, which caused in turn a slight reaction on 44 (*figure 6*) [28]. During the subsequent 7 months of active treatment, in which the length of both 0.018-inch thermal NiTi sectional archwires were increased to continue the distal inclination mechanics of the impacted teeth as the correction progressed, the elastic chain on the left side was also reactivated.

Both impacted teeth were completely recovered in about 11 months of active therapy.

The TADs were definitively removed, and the case was subsequently finished using a standard fixed vestibular edgewise appliance (GC™ Orthodontics Europe GmbH, Breckerfeld), (*figure 7*).

FIGURE 6

Clinical outcome 4 months into treatment showing total disimpaction of tooth 47 and improvement in the position of tooth 37

FIGURE 7

Mounting the fixed appliance to refine the alignment and improve the root position of the second lower molars

Results

At the end of the finishing phase, the acceptable root parallelism of teeth 37 and 47 with good and healthy peri-radicular bone margins and no obvious signs of root resorption are appreciable. Despite this result in posterior area, alignment and radicular tip of anterior teeth could be further improved, but the patient refused to refine these aspects since she received a previous 4-year orthodontic treatment and a severe closed mouth trauma in

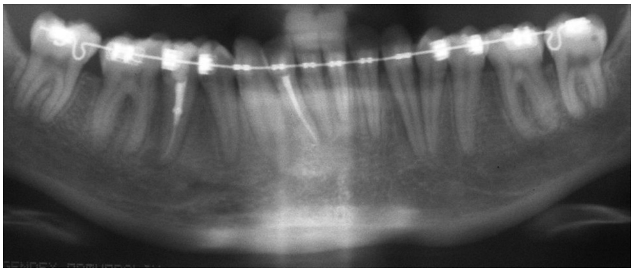

FIGURE 8

Panoramic radiograph showing fixed multibracket equipment in place. Check-up X-ray shows root parallelism in final stages of therapy

FIGURE 9

Post-treatment occlusal intra-oral photo after about 8 months of fixed multibracket therapy showing good recovery of both lower second molars

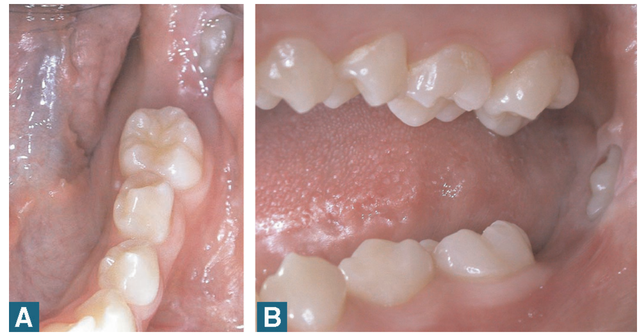

FIGURE 10

Occlusal (A) and left lateral (B) intra-oral photos of the pre-treatment clinical situation of case 2. Tooth 37 is not visible, while tooth 38 appears to be partially impacted

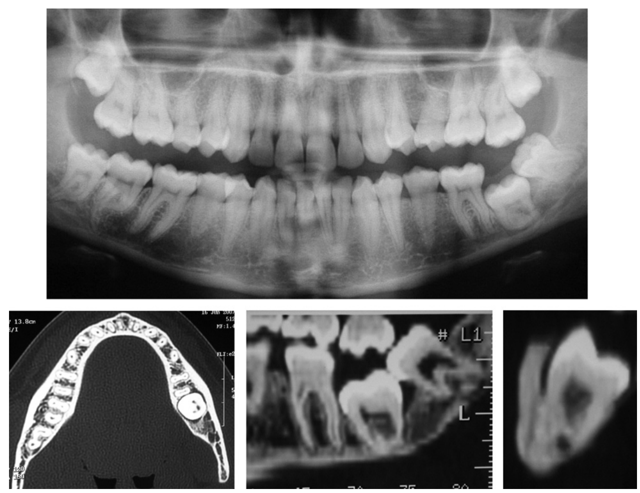

FIGURE 11

Pre-treatment panoramic radiograph showing the deeply impacted tooth 37, which appears to be in contact with the left mandibular alveolar canal (A). Second-level 3D investigation showing the severity of the impaction of tooth 37 on the axial (B), sagittal (C) and coronal (D) planes

the last part of active orthodontic treatment occurred. As a matter of fact, root canal therapies on 42 and 45 have become necessary due to subsequent loss of vitality on such teeth also after 7 weeks from accident (*figure 8*).

Considering the principal aim of the treatment, this case could be considered successful in about 11 months of fixed multi-bracket therapy, achieving good root parallelism of the previously impacted lower second molars, respect to the first molars (*figure 9*).

Case report 2

Diagnosis and aetiology

The second case was a male patient of 22 years of age presenting a very complex clinical condition. Tooth 37 was severely impacted, and tooth 38 had erupted in a mesially inclined position (*figure 10*). Two and three-dimensional radiographic analysis highlighted the severity of the 37 impaction, showing the roots close to the lower edge of the mandible in close contiguity with the alveolar canal. The root anatomy of the impacted tooth was anomalous, displaying a 'hooked' shape (*figure 11*).

Treatment objectives

The patient referred to us with the will to solve the lack of lower left second mandibular molar in order to improve his masticatory function in that side.

Treatment alternatives

Various treatment options were considered. However, any surgical approach to extract the left lower third molar with subsequent surgical repositioning of the impacted lower second molar, or to avulse them, would have a high probability of injury to the mandibular nerve, potentially leading to severe neurological sequelae [29]. After discussion with the patient, he was offered an orthodontic treatment involving orthodontic repositioning of the impacted tooth and subsequent avulsion of tooth 38.

This proposal was accepted by the patient due to its less invasiveness respect to surgical approaches. However, he requested localised intervention in the affected area, rather than more extensive orthodontic appliances; therefore, the use of skeletal anchorage was chosen to minimize the extension of orthodontic appliance.

Treatment progress

The treatment plan devised consisted of two phases, the first to distalize the crown of tooth 38 to obtain adequate mesiodistal space to allow, at a later date, the recovery of impacted tooth 37 via extrusive mechanics. The mechanic used to achieve the first goal was that belonging to "pushing from mesial side" mechanics by means of the dista-screw system [11]. The same system above-described in case report n°1 had been activated by the use a compressed thermal 0.016-inch NiTi sectional wire, after that a quattro® PSM 1.5 × 7 mm miniscrew was inserted in an inter-radicular position between teeth 35 and 36 (*figure 12*). The distalizing force at the level of 38 was created by the superelastic return of the thermal NiTi sectional wire, without the willing to exert any kind of 3D control on this tooth. After about six months of repeated activations, coronal distalization of the 38 had been achieved, creating sufficient space for the subsequent repositioning of tooth 37. To this end, a vestibular tube (GC™ Orthodontics Europe GmbH, Breckerfeld, Germany) was bonded on tooth 36, and a "miniscrew-supported orthodontic pseudo-ankylosis" (MSOPA) system [30] was created by means of a 0.020 × 0.025-inch SS sectional archwire passively connecting the head of the miniscrew to teeth 36 and 38. The system was stabilized by means of flowable composite

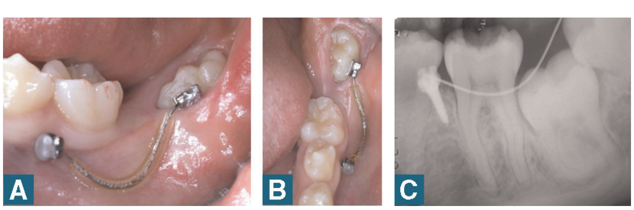

FIGURE 12

Radiographic lateral (A), occlusal (B) and (C) intra-oral views of the dista-screw system mounted at the level of the third quadrant

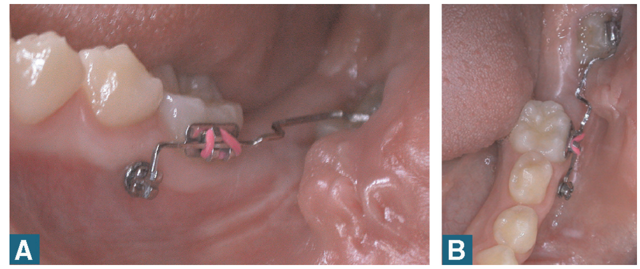

FIGURE 13

Lateral (A) and occlusal (B) intra-oral photos of the MSOPA system with passively modelled 0.020 × 0.025-inch SS sectional appliance

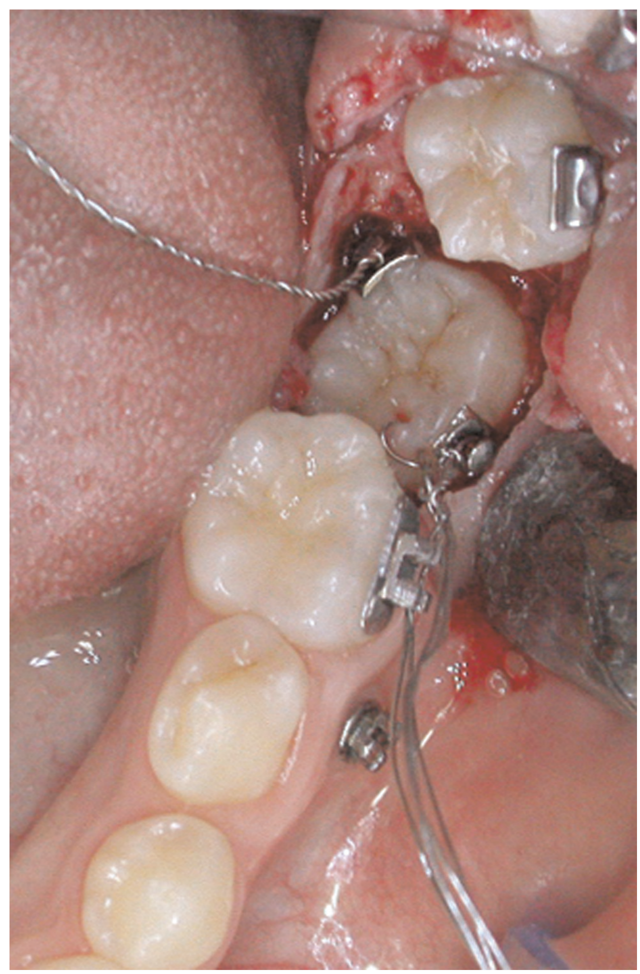

FIGURE 14

Surgical exposure of the impacted 37 and placement of two metal buttons with twisted 0.011-inch SS wires

(Gradia, GC^{TM} Orthodontics Europe GmbH, Harkortstraße, Breckerfeld, Deu) at the miniscrew head; this would ensure indirect anchorage to the system and counteract the intrusive counterreaction exerted on teeth 36 and 38, during extrusive orthodontic traction of impacted 37. The sectional archwire was modelled with an "omega'' stop loop at the end in such a way as to pass across the centre of the alveolar ridge in a mesiodistal direction, in line with the impacted tooth (*figure 13*).
The latter was then surgically exposed, and two metal buttons were positioned, one on its vestibular surface and the other on its lingual surface. Therefore, two 0.011 SS-inch ligatures were applied to each (*figure 14*) and connected to 0.020 × 0.025-inch SS sectional archwire by means of elastic wires reactivated every 15 days (*figure 15*).

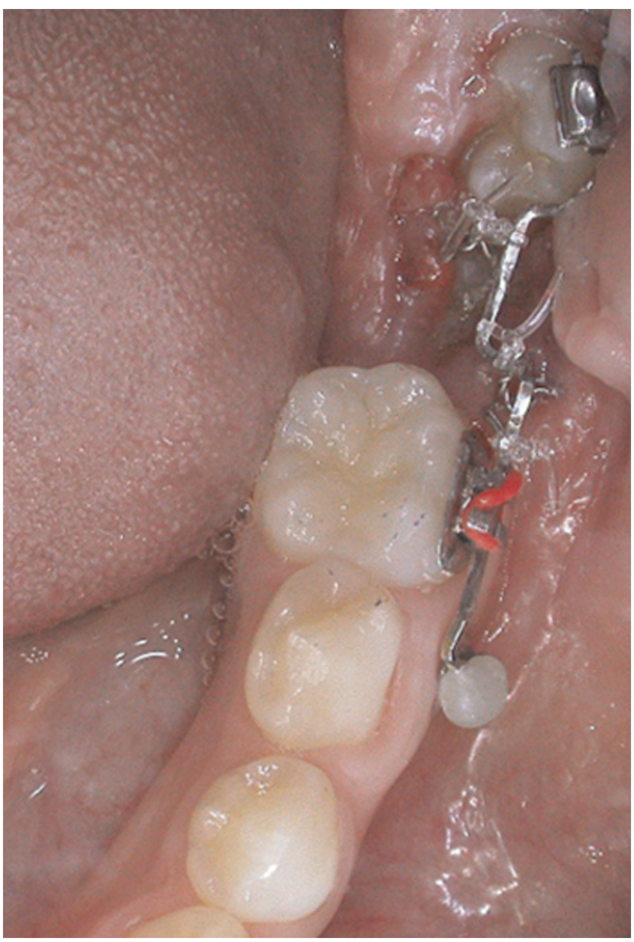

FIGURE 15

Application of extrusive force by activating two elastic wires strained between 0.011-inch twisted SS ligatures and the 0.020 × 0.025-inch SS sectional, modelled every 15 days. The complete recovery of the tooth took 21 months

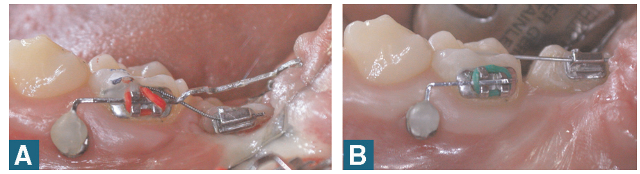

FIGURE 16

Positioning of tube on tooth 37 and application of the twisted 0.016-inch NiTi wire (A) up to the 0.020-inch thermal NiTi (B). The intrusive counterreaction was kept under control by MSOPA-mediated indirect anchorage

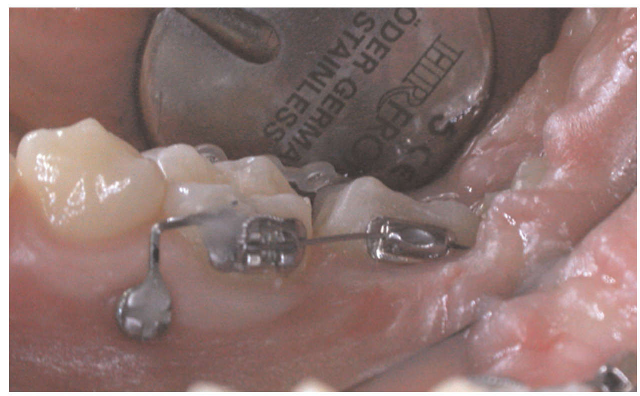

FIGURE 17

Using the 0.017 × 0.025-inch SS sectional and the new MSOPA system with 0.017 × 0.025-inch SS sectional

In a total of about 21 months, repeated activations had brought the tooth crown to the occlusal plane, signalling that adequate disimpaction had been achieved. To finalize the extrusion, a direct tube was applied to the vestibular surface of the 37, and aligned with a series of NiTi wires, beginning with a twisted sectional 0.016-inch NiTi (Speed Supercable, Speed System Orthodontics, Cambridge, Canada) (*figure 16* A) and finishing with a 0.020-inch NiTi (*figure 16*B). Extrusive forces on elements 36 and 38 were counteracted by the MSOPA system, by means of a 0.020 × 0.025-inch SS sectional archwire connected to the miniscrew head.
Finishing was achieved via a 0.017 × 0.025-inch SS wire and a lingual elastic chain, after fixing a metal button on both to the lingual surface of anchorage tooth 36 and 37 (*figure 17*).

Results

The mechanics above-described made it possible to achieve adequate alignment of tooth 37 with good radicular movement (*figure 18*). Final x-rays show the complete recovery of tooth 37,

FIGURE 18

Post-treatment lateral (A) and occlusal (B) intra-oral photos

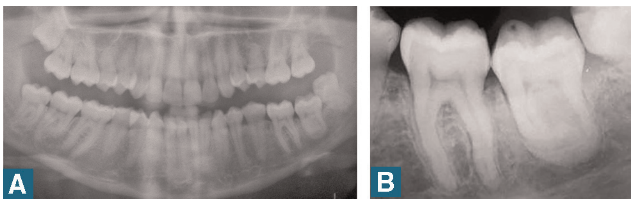

FIGURE 19

Post-treatment panoramic radiograph (A) and peri-apical x-ray (B)

with its roots now more distant from both the lower edge of the mandible body and the mandibular canal (*figure 19*). Therefore, subsequent avulsion of tooth 38 was planned. The treatment objectives had been achieved in about 33 months of active treatment via a vestibular fixed sectional appliance with good control of anchorage guaranteed by skeletal anchorage.

Discussion

The recovery of impacted second molars has traditionally relied on conventional orthodontic methods, without the aid of skeletal anchorage [31]. Although effective, conventional orthodontic approaches are plagued by drawbacks such as prolonged treatment time and the need for bulky appliances extending across the entire dental arch in order to counteract the considerable demand for anchorage.

Hence the surgical approach for recovering impacted teeth has been recommended by many authors [26], but it cannot be considered a risk-free procedure [32].

The two cases reported here show that both direct and indirect skeletal anchorage can resolve even severe cases of lower second molar impaction within a reasonable time-frame.

The biomechanics presented and described here fall into the category proposed by Lee et al., i.e., "pushing from the mesial side" and "pulling from distal side", by exploiting both direct and indirect anchorage [11].

The mechanics of pulling from distal side requires the miniscrew to be placed in a retromolar position, which is often not easy to perform, especially when soft tissues are scarred due to continuous pericoronitis phlogistic phenomena of wisdom tooth and there is little space between the ascending portion of the mandibular ramus and the distal surface of the impacted tooth. What is more, this method is not particularly suitable in situations where a substantial intrusive action via orthodontic forces is required or when the impacted tooth is greatly rotated or lingually inclined [11], so its clinical use must be carefully assessed. On the other hand, this method has some advantages, such as the use of reduced orthodontic appliance (only one bracket or one or more buttons on the impacted tooth) [12], minimum discomfort for the patient, and no adverse effects on neighbouring teeth if the skeletal anchorage becomes unstable. However, miniscrew stability in this area may be reduced by the presence of mobile non-keratinized mucosa, often characterized by scarring, with a marked tendency to mucosal phlogosis around the head of the miniscrew. Therefore, although effective in some situations, this site should not be considered an elective site [33]. Indeed, in the first case presented the right miniscrew lost its stability and it was lost about 2–3 weeks after the beginning of treatment, although it had effectively contributed to the uprighting mechanics of tooth 47 in the very early stages. For the pushing from mesial side mechanics, the "dista-screw system" technique was used in both cases. This technique is based on the use of the direct anchorage from the head of the miniscrew, inserted in an inter-radicular position between the lower first and second premolar or between the lower second premolar and first molar, and by the compression of a round thermal NiTi sectional archwire roughly 35–38 its working length. This technique provides excellent biomechanical efficacy through the exertion of a distalizing, distally inclining and uprighting force, within a reasonable timeframe without the need for a 3D control of impacted teeth. As a matter of fact, considering both the presence of round 1.5 mm hole in the neck of the miniscrews and the fact that flowable composite was used to close the distal extremity of molar tube slot therefore not allowing the full entrance of the sectional wires, the use of rectangular wires for such aim is not advisable due to their poor efficacy [27]. The risk of unwanted movements after loss or mobilization of the miniscrew is also reduced in this case, although a slight mobilization and migration of miniscrews could be occurred occasionally, like in the third quadrant of the first case [28].

In the second case we also used a second pushing from mesial side technique based on indirect skeletal anchorage, by connecting the head of the miniscrew and the tooth to be recovered via a steel sectional wire (MSOPA) [30]. This system immobilized the anchorage units, favouring biomechanical control of the planned movement. An additional advantage of this method is its versatility, as it allows the point of application and direction of the force most conducive to the required movement to be selected. Although in the event of the mobilization of the miniscrew, the anchoring tooth could be subjected to unwanted movements, this risk can be mitigated by frequent periodic visits.

TABLE I
Simplified classification of miniscrew-supported biomechanics for disimpaction of lower second molars.

Direction of orthodontic force	Anchorage
Pushing from the mesial side	
Dista-screw system	Direct
Miniscrew-supported orthodontic pseudo ankylosis (MSOPA)	Indirect
Pushing from the distal side	
Elastic chain on miniscrew placed in retromolar area	Direct

From a brief examination of the methods used, it is evident that the diagnostic framework and intra-oral examination of the characteristics of the patient are of paramount importance in choosing the correct therapeutic approach. Both the direct and indirect miniscrew anchorage methods have their therapeutic indications and techniques of choice, each with their own advantages and disadvantages, which can nevertheless be easily managed by proper treatment planning and, where appropriate, by their combined use. In accordance with the above considerations, a simplified classification of the use of TADs for the recovery of partially or fully impacted second molars is proposed (*table I*).

Conclusions

Severe impacted lower second molars can be well managed and recovered efficiently and effectively through the use of skeletal anchorage and appropriate mechanics. A simplified classification of TADs-mediated biomechanics for this purpose is proposed in order to simplify the diagnostic framework and facilitate understanding of the biomechanics used, and communication between clinicians.

Disclosure of interest: the authors declare that they have no competing interest.

Author contributions: Nicola Derton: conception and design of the treatment.
Mario Palone: drafting the manuscript.
Luca Lombardo, Palone Mario and Nicola Derton: revising the manuscript critically for important intellectual content.
Approval of the version of the manuscript to be published: Luca Lombardo, Mario Palone, Nicola Derton, Francesca Cremonini, Paolo Albertini, Giuseppe Siciliani.

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