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TITLE

"Canine first technique" in maxillary impacted canines: analysis of the treatment duration and the success of therapy.

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INTRODUCTION

1.1 The canine and its role

Canine teeth play an important role to ensure a good aesthetics, lip support, and masticatory function (Fagade, Gillbe, & Wastell, 1988) (Counihan & Hegarty, 1997). In addition, canine contribute to disarticulation during lateral movements (Taylor, 1998). The correct eruption, the position and the morphology of the canine on dental arches give a health condition to the mouth. Eruption disturbance of the canine can cause a sequel of problems to adjacent teeth, such as internal or external resorption or a loss of space on dental arches. Impacted canine represents a real problem in orthodontic practice and an early diagnosis and an equally timely treatment can be the right approach for a good result (Beadnell, 2012).

1.2 Dental Inclusion

The impacted tooth is considered an eruption disturb. The term "eruption" indicates the movement of a tooth from its position in bone to the oral cavity. With the eruption, the tooth takes a functional position in the mouth and this dynamic process includes the complete development of the root, the formation of nearby tissues and an establishment of occlusion (Nolla, 1960). Literature reports that the normal eruption of teeth is influenced by racial, sexual and individual factors and occurs in a specific age (Schour & Massler, 1941) (Moorrees, Fanning, & Hunt, 1963).
Anomalies of the normal sequence of eruption or a different position are frequently found during the clinical practice. Anomalies of eruption are generally distinguished into two categories: anomalies relative to position and disorder related to time. Transposition and ectopic eruption are classified such

as anomalies relative to time and instead, premature eruption and delayed eruption are considered Eruption anomalies relative to time (Huber, Suri, & Taneja, 2008). There are many terms to describe the anomalies of the dental eruption (Delayed eruption, Impacted teeth, Primary retention, etc…) but we want to focus our attention to analyse the difference between a retained (embedded) tooth (late/retarded) and an impacted tooth. The tooth is considered retained (embedded) when it is radiographically present into the alveolar bone but clinically the teeth is absent in the oral cavity considering the age of the patient. A retained tooth hasn't lost its eruptive potential because it hasn't complete its root development (Suri, Gagari, & Vastardis, 2004). A tooth is defined impacted when it is clinically absent in the oral cavity, after complete root development or the contralateral teeth is erupted for more than 6 months and has finished the root formation (Lindauer, Rubenstein, Hang, Andersen, & Isaacson, 1992). The term Transmigration identifies an impacted and migrated tooth across the midline by more than half of its length (Daskalogiannakis, 2000). It's a rare phenomenon especially for mandibular canine (Dalessandri, Parrini, Rubiano, Gallone, & Migliorati, 2017). There are few articles, in literature, about transmigration and often they are cases-reports. Analyzing 127 patients, Mupparapu proposed a classification of lower transmigrated canine into 5 types considering its inclination to the midline (Mupparapu, 2002). The prevalence of mandibular canine impaction is between 0.92 and 5.1% and the transmigration is hovering from 0.1 to 0.31 % (Dalessandri, Parrini, Rubiano, Gallone, & Migliorati, 2017). The dentist considers an impacted tooth a diagnostic trial. The management of this problem is a daily challenge for most orthodontists and the final result is unpredictable (Kokich, 2004). The most preferred treatment is early diagnosis and an orthodontic interceptive approach but, when the age of patient doesn't allow this management, a surgical exposure

and orthodontic alignment are appropriate to apply (Becker, Zilberman, & Tsur, 1984) (Bishara, et al., 1976).

1.3 Development consideration

The maxillary canine generally erupts at the age of 10,5 years old in girls and at the age of 11,5 years in boys (Hägg & Taranger, 1986) (Shapira & Kuftinec, 2001). The eruption of maxillary canines is long and difficult. Authors believe that eruption path of a maxillary canine is about 22 mm (Coulter & Richardson, 1997). The canine tooth starts its path of development laterally to piriform fossa, near the maxillary sinus. The permanent canines's crown are situated in the proximity of the distal surface of lateral incisors's root and they are situated apically near the mesial surface of the first premolar. After the first premolar eruption the canines change their mesial inclination into a distal angulation (Van der Linden, 1983). During the first stage of its development, the canine, at the age of 3 years, is located in high part of the maxilla and it is angulated mesially and lingually. At the age of 8, changing its angle, the canine starts its buccal travel towards the root apex of its corresponding deciduous tooth. This is the most important phase of the canine's migration because in this stage it can get palatally impacted (Becker, 2007). The maxillary canines, in the first phases, normally have a mesial pathway of eruption but, when they meet the lateral incisors, they place vertically around the occlusal plane, with the guide of the lateral incisor root. Instead, if the lateral incisors are absent, the maxillary canine can erupt taking the place of lateral tooth (Nanda, 1983). Authors believe that eruption path of a maxillary canine is about 22 mm (Coulter & Richardson, 1997) . The maxillary canine generally erupts at the age of 10.5 years old in girls and at the age of 11.5 years in boys (Hägg & Taranger, 1986) (Shapira & Kuftinec, 2001). At the age of 13.1 in males and 12.3 in girls, if the canine doesn't make its

appearance in the oral cavity, it's considered a sign of a delayed eruption (Hurme, 1949).

1.4 etiology of impacted canines

The etiology, of maxillary impacted canine, is unknown but the authors hypothesize a multifactorial and genetic origin (Pirinen, Arte, & Apajalahti, 1996). As Becker and Chaushu suggest, the causes of impacted canine can be divided in 4 categories:

- Local pathology
- Genetic and hereditary factors
- Local obstruction
- Anomaly of the normal eruption of lateral incisors

(Becker & Chaushu, 2015)

The causing factors of impaction of canines include problems during tooth eruption sequence, absence of space, trauma, retention of primary canine, early root closure, rotation of tooth buds, formation of pathological lesions (such as follicular cysts or odontomas), canine tooth ankylosis, recurrent infections, pain, internal resorption or external resorption of the canine and adjacent teeth, or a coincidence of some of these (Alqerban, Jacobs, Lambrechts, Loozen, & Willems, 2009) (Bishara, 1992). Primary retention is defined as stopping the eruption of a tooth without it being possible to determine local obstruction as a cause (Raghoebar, Boering, Vissink, & Stegenga, 1991)and it is often caused by genetic disturbance (Bishara, 1992). Instead the impaction caused by an obstruction is called secondary retention (Raghoebar, Boering, Vissink, & Stegenga, 1991). The aetiology of palatally impacted canine is unknown but some authors hypothesize a multifactorial and genetic origin (Pirinen, Arte, & Apajalahti, 1996). Labial impaction of a maxillary canine is supposed to be caused by an ectopic migration of the canine's crown over the root of the near lateral incisor

or it is due by a movement of the maxillary dental midline that reduce the space for the eruption of the canine (Kokich, 2004). The maxillary cuspid follows a more difficult and tortuous path of eruption than any other tooth. At the age of 3 it is high in the maxilla, with its crown directed mesially and somewhat lingually. It moves towards the occlusal plane, gradually uprighting itself until it seems to strike the distal aspect of the root of the lateral incisor. It seems to be deflected to a more vertical position; however, it often erupts into the oral cavity with a marked mesial inclination" (Moyers, van der Linden, Riolo, & McNamara, 1976). Although to date a genetic cause is widely demonstrated for the palatally impacted canine (Becker & Chaushu, 2015), it's important to dwell about the theories that, throughout history, has been formulated to explain the aetiology of impaction of the canine. To explain the etiopathogenesis of the impacted canine(s), the reference is made to the two major credited theories: "guidance theory" and "genetic theory".

The **"guidance theory"** affirms that developmental problems of upper lateral incisors bring to an excess of space in the apical region of maxilla during the eruption process of permanent canine and it loses the "guide" indicated by the roots of adjacent teeth (Becker, Sharabi, & Chaushu, 2002). If the lateral incisors are absent or are malformed, it will be an excess of space in which the canine could shift from the buccal to the palatal side (Brin, Becker, & Shalhav, 1986).

The "**genetic theory"** was demonstrated by several works (Peck, Peck, & Kataja, 1994) (Pirinen, Arte, & Apajalahti, 1996) (Garib, Alencar, Lauris, & Baccetti, 2010). Many common features were found in patients with impacted canine such as less distance at level of the maxillary canines or a smaller morphological shape of the teeth (McConnell, Hoffman, Forbes, Janzen, & Weintraub, 1996) (Jacoby, 1983) (Becker, Sharabi, & Chaushu, 2002)(Langberg BJ, Peck S. ;2000).

1.5 Epidemiology of impacted canine

After the lower third molar ,this developmental anomaly is the most frequent (Celikoglu, Kamak, & Oktay, 2010) with a prevalence between 0,9% and3,3% (Bishara, 1992) (Cooke & HL., 2006) (Ericson & Kurol, 1986).The probability to observe a mandibular canine impacted is less than twice than that in the maxilla (Ericson S, Kurol J. ;1988; Hitchin AD. 1956; Dachi SF, Howell FV.;1961;) and in 85% is more frequently located palatally than labially(15%) (Bishara, 1992) (Cooke & HL., 2006) (Ericson & Kurol, 1986) (Grover & Lorton, 1985) (Warford, Grandhi, & Tira, 2003).The incidence of canine impaction is 2:1 in girls than boys and in8% of cases it is bilateral (Litsas & Acar, 2011).

1.6 Diagnosis of impacted canines

1.6.1 Visual Inspection

Considering the patient's age, an intraoral clinical examination is the first step in formulating a correct diagnostic hypothesis. Some authors believe that some clinical signs could give the suspicion of the presence of an impacted canine: i.e. the permanence of deciduous canine beyond 14 to 15 years old of age, the absence of a canine bulge, or its palatally presence or a deviation of the normal tip of the lateral incisors (Ngan, Hornbrook, & Weaver, 2005).

1.6.2 Palpation

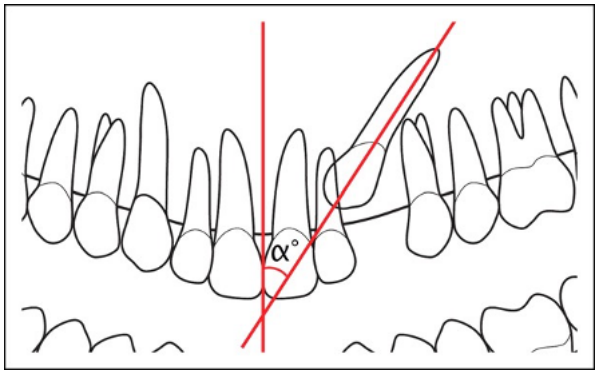
The palpation is made on both palatal and buccal side of the alveolar process, in the canine region. The palpable buccal bulge, placed distally to the maxillary lateral incisor, on the buccal surface of the alveolar bone, is an important diagnostic tool to find the position of the maxillary canine (Kettle, 1957). The absence of a palpable bulge is considered abnormal and the presence of a little concave contour of the alveolar bone mesial to the deciduous canine can reveal anomaly of eruption (Ericson & Kurol, 1986). Lateral incisors also play an important role. The "*ugly duckling*" stage occurs during the mixed dentition and

is characterized by a presence of midline diastema and by a flared lateral incisors. These abnormal position is caused by the pressure of the eruptioning canines (Broadbent, 1941) (Proffit, Fields, & Sarver, 2007). If they are tipped distally or buccally may be the alarm of an eruption disturbance (Moss, 1972, &), 1972) (Bishara, et al., 1976). During this phase, it's necessary don't treat orthodontically the patient because, otherwise we could cause a resorption of the roots of the lateral incisors.

1.6.3 Radiographic exams

In addition to inspection of oral cavity and palpation, the radiographic examinations are important to perform a correct diagnosis (Sajnani & King, 2012). Routine radiographic controls are suggested from the start of the eruption of the incisors or from 9 years old of age to intercept an animal eruption of the canine and is also recommended, if the canine's bulge in unpalpable, at the age of 9 years until the bulge is touchable and in older children(>11yr) without erupted canines (Bergsrom, 1976) (Lind, 1977). The necessary informations may be obtained by periapical films, panoramic view, lateral cephalograms or occlusal views (Bishara, 1998). Ericson and Kurol, in an article of 1988, proposed to use 3 geometric parameters, detectable on the panoramic radiographs:

1)Alpha angle: it represents the angle between the long axis of the impacted tooth and the midline. If the alpha angle is bigger than 22°, the prognosis is unfavourable.



2)***Sector*** in which canine's cusp is located. (s)

The authors have identified 5 sectors:

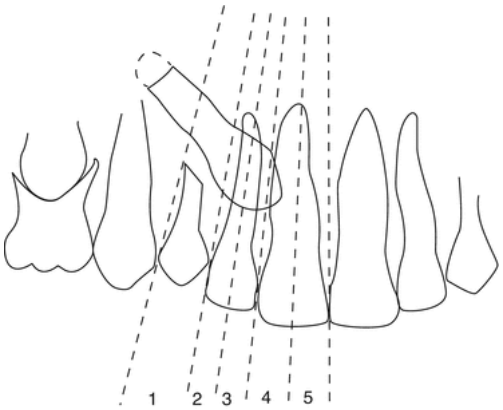
Sector 1: the canine is located in the normal site of eruption

Sector2: the cusp is located between the tangent line to the distal surface of the lateral incisor and its long axis

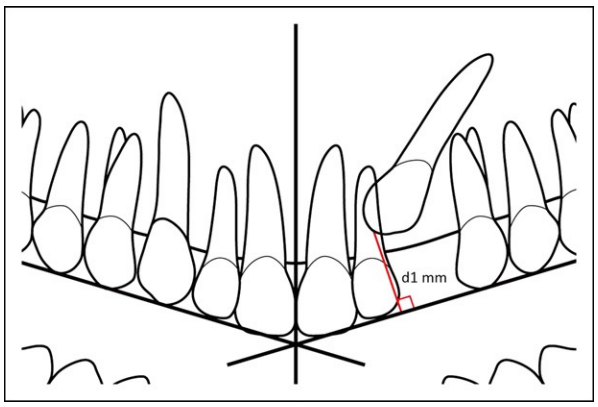
Sector3: the cusp is located between the long axis of the lateral incisor and its mesial surface

Sector4: the cusp is located between the tangent line to the distal surface of the central incisor and its long axis

Sector5: the cusp is positioned between the long axis of the central incisor and the tangent line of its mesial surface.



3) ***Distance*** measured between the cusp of the impacted canine and the occlusal plane.



1.7 General considerations about treatment choice

To approach the management of the impacted canine, a multidisciplinary assessment is necessary. The age of the patient, the oral health or the skeletal stage of growth, in association with a radiographic exam, are essential to evaluate the possibility of the eruption of the impacted canine (Mc Sherry PF;1996). Different treatment options are available: no treatment, interceptive treatment, extraction of the impacted canine, autotransplantation of the canine, surgical management + orthodontic treatment (Cozza, Mucedero, Ricchiuti, & Baccetti, 2010) (Bishara, 1998) (Naoumova, Alfaro, & Peck, 2018)

1.7.1 No treatment

1.7.2 Interceptive treatment

Extraction of the deciduous canine: the clinical protocols suggest the extraction of the equivalent deciduous tooth, with or without an orthodontic treatment used to expand the maxilla (Mcconnell, Hoffman, Forbes, Jensen, & Wientraub, 1996) (Olive R. , 2002). Since 1936 the interceptive extraction of the primary canine was considered the best solution to make the eruptions of the maxillary impacted canine easier. Some studies show that this approach could be prevent the risk of resorption (Buchner, 1936).

Extraction of the deciduous canine + orthodontic treatment: Olive suggested to resolve the impaction of the canine using only an orthodontic treatment. For Olive , in the 94% of a group of patients with palatally impacted canine, the only extraction of the corresponding deciduous canine can help to reduce the severity of the impaction and the association of the deciduous canine extraction and the orthodontic treatment allows the total eruption of the impacted tooth when the cusp does not go beyond the long axis of the adjacent tooth (Olive R. , 2002) (Olive R. , 2005).

Distalization of the posterior sectors +extraction of the deciduous canine:

Extraction of a deciduous canine alone is considered helpful and efficient method to promote the eruption of maxillary PDC but with the additional use of a cervical-pull headger can help to raise the percentage of succeeding approximately three times (Baccetti, Leonardi, & Armi, 2008). The use of the cervical-pull headger avoids the mesial migration to the residual space of the extraction of the deciduous canine of the teeth that are distally positioned to this space (Baccetti, Leonardi, & Armi, 2008).

Extraction of the deciduous canine + extraction of the first molar: Some authors propose the contemporaneous extraction of the primary canine and the first molar to prevent palatally or centrally in the alveolar crest displaced canine and this procedure in able to avoid the risk of incisor root resorption (Bonetti, Zanarini, Marini, & Gatto, 2011). As they suggest is appropriate and useful to apply this protocol between 8 and 13 years of age. The double extraction allows the eruption of the impacted canine and the contemporary uprighting of the first premolar that stimulate a correct alignment of the canine in eruption. (Alessandri Bonetti, Incerti Parenti, Zanarini, & Marini, 2010).

1.7.3 Extraction of the impacted canine

1.7.4 Autotransplantation

These interceptive approaches are especially useful in the adequate situations but, is often necessary, to guide impacted canine into correct position, to have a surgical-orthodontic treatment (Mathews & Kokich, 2013).

1.7.5 Surgical exposure

Three methods, for Kokich, to expose a labially impacted canine: gingivectomy, apically positioned flap or applying closed eruption skills (Bedoya & Park, 2009) (Kokich, 2004). The surgical procedures used to expose an unerupted canine are classified into open or closed techniques.

1.8 Labial Impaction

In case of a labial impaction, there are 3 methods for exposing an impacted canine:

1)excisional uncovering

2)apically positioned flap (Vanarsdall & Corn, 1977).

3)closed eruption techniques (Kokich & Mathews, 1993).

Excisional uncovering approach is a very easy treatment and it's often used by orthodontists. In this case the labial impacted canine is covered by a thin and small layer of mucosa and the crown is palpable under the fingers. A semilunar window is made to expose the tooth through the oral mucosa (Becker & Chaushu, 2015).

APF: a partial thickness flap is drawn from the keratinized gingiva at the crest of the ridge or, in case of retained deciduous canine, the flap origins from the gingival margin. It incorporates a thick band of attached gingiva and, after it has been raised above dimension of the impacted canine, the flap is sutured apically on the tooth, exposing half of the crown (Vanarsdall & Corn, 1977) (Vermette, Kokich, & Kennedy, 1995).

The Closed eruption procedure provides the creation of a partial thickness flap drawn from the keratinized gingiva at the crest of the ridge. When the follicle of the canine is open a little more over the middle of the crown, the aperture is extended to place a small attachment. After the attachment's bonding, a gold chain or twisted steel pigtail ligature is positioned on the downside and stay in place by the sutured margin of the flap (Vermette, Kokich, & Kennedy, 1995) (Heaney & Atherton, 1976). As suggested by V.G. Kokich, the orthodontist should consider 4 criteria to choose the best method for uncovering the unerupted canine:

1) labiolingual position of the crown.

It's important evaluate the thickness of bone that covers the crown of tooth because, when the canine is positioned labially, being minimum the quantity of bone, all 3 surgical techniques can be used. If canine is within the alveolus, should be chosen a closed eruption technique for avoiding an excessive removal of bone from the surface of the crown.

2)vertical position of the canine considering the mucogingival junction.

If the crown is placed coronally to the muco-gingival junction, is possible to use all 3 techniques. If it's positioned apical to the said junction, should be used a closed eruption technique (Becker, Brin, Ben-Bassat, Zilberman, & Chaushu, 2002). If is use an excisional technique, after surgery, a small amount of gingiva will remain over the labial surface of the tooth after its eruption. Besides an apically positioned flap would be inappropriate, if the crown is positioned considerably apical to the muco-gingival junction, because it will an unstable crown and a re-intrusion of the tooth after orthodontic treatment (Vermette, Kokich, & Kennedy, 1995) .

3)amount of gingival in the area of the unerupted canine

If there are 2-3mm of attached gingiva over the crown after canine's eruption, any of the three techniques can be used but, if the quantity of gingiva is considered insufficient, should be chosen an apically positioned flap.

4)mesiodistal position of the canine crown.

Finally, it's necessary to observe if the crown of the tooth is positioned mesially and over the root of the adjacent lateral incisor because, in this case, it is useful to approach with an apically positioned flap. Orthodontic traction helps simulate the physiological eruption process. If the orthodontist choose the Closed eruption, the orthodontic traction will allow the tooth to erupt at the centre of the crest of the alveolar bone without migration of the marginal gingiva or without the creation of the bone resorptions (Crescini, Nieri, Buti,

Baccetti, & Pini Prato, 2007). Selecting an open technique, could be applied elastomeric chain to guide the impacted canine's eruption. The application of both surgical techniques will also give the maintenance of a good periodontal health (Vermette, Kokich, & Kennedy, 1995).

Midalveolar canine and Tunnel technique

The midalveolar position of the impacted canine is often caused by a mesioangulated canine. The surgical access is vestibular and is necessary that a big quantity of bone is taken away. The result therefore is a long and unsightly clinic crown supported by a lower amount of bone. As Crescini suggested, to reduce these problems, in his tunnel technique the space for the canine is created by an orthodontic treatment before the surgery. In a second moment, the extraction of the primary canine is performed and then a full flap is drawn and elevated from the cervical margin of the near lateral incisor, passing through the primary canine and the premolars. The crown of the impacted canine is minimally exposed in the labial side and an attachment is bonded on this surface. At the end, the metal ligature is passed through the osseous tunnel that result from the extraction of the primary canine. During the orthodontic traction, the canine crosses the bone tunnel and it erupts in place of the deciduous canine (Crescini, Clauser, Giorgetti, & Cortellini, 1994).

1.9 Palatal Impaction

Regarding palatal impaction two different approaches are described in literature, to encourage the canine's eruption. One option is to proceed to uncover the impacted canine before applying the fixed-orthodontic treatment and wait the autonomous eruption of the tooth. The other approach is to perform orthodontic treatment first, wait for the creation of space necessary for the alignment of the canine and only at that point proceed to the uncovering

surgery. Some orthodontists suggest that carry out the surgical exposure after the orthodontic treatment. In the first time, brackets are positioned on the other teeth of the maxillary arch to create space for the alignment of the canine. Only in a second moment, the clinician proceeds to the surgical uncover. After a short period, with the help of some devices of traction, the canine will align in the alveolar ridge (Johnston, 1969) (Kokich & Mathews, 2013). Another current of thought, supported by Kokich and Mathews, purpose the early surgical uncovering before starting the orthodontic therapy (Kokich & Mathews, 2013). With this method, a full flap is drawn and elevated where the canine is positioned. After the removal of all the palatal bone that is located down the CEJ, the mucoperiosteal flap is repositioned and is sutured in the original position but, before this phase, a hole is done on the flap in the area of the crown of the impacted canine. The canine erupts naturally after 6-8months and, only when the cusp is aligned with the occlusal plan, a bracket or an orthodontic device will be positioned to moved it labially. The effectiveness increases Especially if this therapy is applied during the mixed dentition (Kokich & Mathews, Impacted teeth: surgical and orthodontic considerations., 2001). In this case, we have two kind of surgery: open and closed. The impacted canine, in the open exposure technique, will be permanently exposed in the oral cavity after the dental follicle, oral mucosa and all the palatal bone down the CEJ have been removed. It is important to pay attention to the fact that the healing of the surrounding tissues does not cover the crown of the impacted canine. Like Becker suggested, to bypass this problem, should be removed the entire dental follicle, a wide zone of oral tissue and bone, down the CEJ and should protect the area using a surgical pack. When the pack is removed, is possible to proceed to the bonding of an attachment. An excessive removal of the bone and oral mucosa or going beyond the CEJ could affect the final result of the treatment causing for example apical migration of the gingival margin (Becker,

Abramovitz, & Chaushu, 2013). We must be quite careful to avoid an excessive loss of soft tissue and bone because, at the end of treatment, the periodontal tissues should be irremediably damaged (Kornhauser, Abed, & Harari, 1996) (Becker, 2010) (Chaushu, Chaushu, & Becker, 2004) (Becker, Chaushu, & Casap-Caspi, 2010) (Becker, Chaushu, & Chaushu, 2010). Instead of, with the closed exposure technique, the orthodontic attachment is positioned simultaneously the surgery on the palatal impacted canine. A small exposure of the crown is realized to bond the attachment. With this approach isn't necessary going beyond the CEJ and this is perfect for the deep impacted canine (Becker & Chaushu, 2013). Parkin et al. suggest that if the canine is located in sector 3-4(moderate- severe impaction) is helpful an open exposure to stimulate its eruption and this treatment id considered more predictable (Parkin, Almutairi, & Benson, 2019). Even for Naumova the patients that have been subjected to the open procedure respond better to the treatment in terms of compliance, although the waiting times for the eruption of the impacted canine are considered overlapping (Naoumova, Rahbar, & Hansen, Glass-ionomer Open Exposure (GOPEX) Versus Closed Exposure of Palatally Impacted Canines: A Retrospective Study of Treatment Outcome and Orthodontists' Preferences, 2018).

1.9.10 Tads

The repositioning of the canine in the arch takes place through three fundamental phases:

1. Extrusion
2. Repositioning
3. Alignment

For the first two phases, levers may be used because they offer three-dimensional control of the dental element for optimal repositioning in the arch and they are a statically determined system. For convenience, in orthodontics

the statically determined systems are those that at one end create a pair, while on the other have only one force (not a pair of forces). This means that a lever to be defined as such must be inserted in a tube or bracket on one side but must be tied on the other side in a point manner. The levers are made in TMA 0.019x0.025(Ormco, Orange, Ca, US). Like Bishara suggested, light forces must be applied to avoid the resorption or the ankylosis of the periodontal ligament. The forces shall be less than 60g (2 once). The movements to be carried out to dis impact a palatally displaced canine are extrusion, distalisation and vestibularization. The path of the force, in the first phase of the movement for disimpaction, should be directed to move the canine away from the adjacent roots of near teeth (Bishara, 1998). A good option is the use of close-coil spring (Bishara, 1998). Another key and crucial element in canine disinclusion is the creation of anchoring units, whether dental or bony. The term anchorage means the application of a resistance that opposes the unwanted movement of teeth (Daskalogiannakis, 2000). Control the anchorage means also to prevent the action of very light forces and ,for this reason ,the clinician search to have an Absolute anchorage (Weinstein, Haak, Morris, & Attaway, 1963) (Pilon, Kuijpers-Jagtman, & Maltha, 1996). Anchorage is considered infinite or absolute when, during the movement of the teeth, there is no loss of its. Ankylosed teeth or dental implants can be used to obtain the anchorage (Melsen & Garbo, 1999). The Miniscrews/ miniimplants fixed to bone are devices used to have skeletal anchorage. the term Tads means the same devices that are temporarily fixed to have the anchorage (Cope, 2005).The major part of all miniscrews/miniimplants have high biocompatibility, they are made of medical type IV or type V titanium alloy (Papadopoulos & Tarawneh, 2007). Although their very definition implies that there is osteointegration, a complete osseointegration is unwanted during their orthodontic application, so miniscrews are made with a smooth surface to

reduce their integration with the bone (Carano & Melsen, 2005) (Melsen & Costa, 2000) (Deguchi, et al., 2003).

Tads are considered necessary if a skeletal anchorage is required to move only an impacted tooth before a fixed orthodontic treatment is applied. These devices are frequently used during the orthodontic practice for their ease of use, positioning and removing. They are, also, cheap and accepted by the patient (Papadopoulos & Tarawneh, 2007). The disadvantages related to the use of these devices are negligible and do not inhibit subsequent treatments (Liou, Pai, & Lin, 2004). Tads are considered an efficiency solution for the extrusion of the impacted canine (Kocsis & Seres, 2012).

They are able for a lot of application, including the extrusion of the impacted canine (Park, Kwon, & Sung, 2004) . Considering their use to promote canine eruption, Tads are positioned, in the first phase, in the alveolar process to increase the canine inclination. If it's applied an open exposure, after the cure of the near soft tissue, a traction force of 0.5-0.8N closed coil-spring is applied using a NI-TI. The best advantage of this solution is that is not necessary to apply the fixed-orthodontic treatment until the eruption of the impacted canine and there is lower risk of ankylosis. (Kocsis & Seres, 2012) (Heravi, Shafaee, Forouzanfar, Zarch, & Merati, 2016). In our study we have frequently used Tads. The absolute anchoring given allows to avoid a whole series of side effects that may occur during clinical practice if a dental anchorage is preferred. Especially, at the level of the first molar, could happen:

- flaring
- intrusion
- the tip directed crown-medial carding by the anticlockwise moment of the system

(Melsen, Mini-implants: Where Are We? , 2005).

The use of the miniscrews, during the treatment for the disimpaction of the impacted canine, provides a number of advantages:

- Absolute anchorage
- Reduction of treatment times
- Aesthetic orthodontics
- Minimum discomfort

All these 4 points have been very important to purpose this new approach: the "canine First" technique. This treatment, also with the use of Tads, allows to have the best anchorage during in situations where the latter is considered critical, insufficient or in cases where you want to avoid unwanted side effects, with a significant reduction in treatment times related to the control of unwanted effects on the dental arch. The aesthetics is high because the fixed-orthodontic treatment is not bonded until the canine has almost reached its ideal position, increasing the patient's compliance.

2.AIM

The purpose of this study was to evaluate the eruption time of maxillary impacted canine treated by the "canine first technique" and to assess the success rate of the number of erupted canines in a young population and in an adult's one.

3.MATERIALS AND METHODS

The retrospective trial was conducted at the Department of Orthodontics of the School of Orthodontics at University of Federico II in Naples and the study participants were enlisted between 2014 and 2019. A total of 103 medical charts and panoramic radiographs of 103 patients, who were treated in the Department of Orthodontics of the School of Orthodontics at University of Federico II in Naples, were available for the study.

The inclusion criteria were:

- unilateral or bilateral PDCs treated with surgical exposure and planned for orthodontic alignment.
- canine cusp tip position (documented by panoramic radiographs) from long axis of lateral incisor greater or equal to sector 2. (Ericson & Kurol, 1988) (Leonardi, Armi, Franchi, & Baccetti, 2004)
- alpha angle >10°
- Age from 13-36 aa

Impacted canines were 131, of which 6 mandibular and therefore excluded from the observations. The following conditions were considered as additional exclusion criteria:

- craniofacial anomalies
- congenital syndromes of craniofacial interest
- periodontal disease,
- temporomandibular disorders.

The data in the clinical records and the radiographic examinations have been designed to locate and confirm the presence of the impacted canine. (Hunter, 1981). The study was exclusively carried out on radiographic and clinical evaluations (panoramic radiographs and data, already present in the archive) of subjects in treatment and no longer in treatment. The patients were subjected to the surgery for the recovery of the impacted canine through the approach "Canine First" (Bishara, et al., 1976). The "canine First" technique consists in the surgical approach to the impacted canine before starting the fixed-orthodontic treatment. The procedure is a united surgical- orthodontic treatment of palatally impacted canines. In the study one of the next surgical technique was employed according to the need of the individual patient: open exposure, closed technique or APF, but the Tunnel Technique was never used (Parkin, No Difference in Surgical Outcomes Between Open and Closed Exposure of Palatally Displaced Maxillary Canines, 2012). To encourage the eruption of the impacted canine,

some auxiliary orthodontic devices were applied. The "canine First" allows that Tads are frequently applied to have a direct and absolute anchorage. The Type IV titanium mini implant is chosen and is positioned with an insertion torque at least of 35N, calculated by dynamometer.

3.1. Clinical variables of interest

The sample was divided:

- By age into two groups: under16 and over16
- By sex into two groups: feminine and masculine
- By alpha angle into two groups: >22° and <22°

A comparison was made between the eruption times of the canine located in the Sector 2 against the canines located in the sector 3, sector 4, sector 5 ad their relative percentage of success of eruption. All participating entities have been assigned an identification code and the same thing was made for the corresponding impacted canine. To the interns of the orthodontic department who had in care the subjects an identification code was assigned, to guarantee a better correspondence in the crossing of data and so that the data can be processed anonymously. The file containing the data in nominal form, associated with the assigned identification code was kept as a confidential document, accessible only to the study manager and his collaborators, at the testing center. Considering the descriptive nature of canine eruption time in principle, it was possible to calculate the amplitude of the confidence interval that was observed. With a minimum of 80 observations and expecting to have a median eruption of around 4-5 months, the 95% confidence interval had an amplitude of about 2 months. With a censure rate of 20%, data were collected for at least 100 canines.

3.2 Primary Outcome measures

The sample thus collected were, then, studied and divided by age, waiting times and success rate of canine recovery. The median time of observation of the subjects was 14.1 months. The recovery times of the impacted canines was determined on the basis of the data present in the clinical records of the patients. The date of the surgery and the date of the first post-surgical check in which the canine crown was visible in the arch were taken into consideration to find the primary outcomes. The date of entry into the study corresponds to the date of intervention while the date of eruption or last visit was taken into account for the final calculation. The time of the eruption was measured in days/months from the day of surgery to the eruption or to the date of the last clinical control.

3.2 Secondary Outcome measures

The percentage of success of such operations was evaluated on the basis of the data present in the clinical records of the patients. The success rate was determined by the percentage of crowns of canines visible in the oral cavity after treatment. We agreed that in order to read the available clinical data the number 1 was a success and the number 0 was a failure. The alpha angle and the sector position of the cusp were measured in panoramic radiographs. After the diagnosis had been confirmed from the clinical records and radiologic data, previous panoramic radiographs, were analysed to evaluate the position of the impacted canine. All panoramic radiographs were studied in a darkened room by using a diaphanoscope (Sajnani & King, 2012). The radiographs were drawn with matte acetate tracing paper and a 0.3mm HB fine pencil and, to measure all parameters, the protractor was used. The midline was determined as the line passing between the anterior nasal spine and the alveolar process. The canine sectors included in this study were from Sector2. The occlusal plane of reference is given by a horizontal line that passes between the central incisors and the

cusp of the first permanent molar (Ericson & Kurol, 1988) (Leonardi, Armi, Franchi, & Baccetti, 2004). In the absence of the central incisor or of the first molar, the lateral incisor and the second permanent molar were taken as reference, while in the case of mixed dentition, the horizontal line between the margin of the central incisors and the second molar was taken as the occlusal plane. Panoramic radiograph was assessed, where necessary, taking into account the degree of distortion of the image. On each opt was evaluated the alpha angle and the sector of Ericson-Kurol corresponding to the position of the cusp of the impacted canine. The analysis of these data and radiographs was carried out by two clinicians that are specialists in orthodontics and with experience in the field. The information collected from the orthodontic folders was divided as follows:

Before starting treatment

- General anamnesis: name, sex, date of birth;
- Medical anamnesis: relevant diseases, hospital admissions, drug use, allergies, pregnancy status, smoker,
-Panoramic X-ray of dental arches
- Date of surgery

After 12 months or at the last check date:

- Date of the canine eruption (if present)

3.3 Statistical Methods

The variables of interest were first analysed using descriptive statistics. Continuous variables were expressed as mean and standard or median deviation and ranges, depending on the distribution of data, while categorical variables were expressed as absolute and relative frequencies. Median follow-up time was evaluated using the inverse Kaplan Meier procedure.

The primary outcome (canine eruption) was analysed using the Kaplan-Meier

curves and the median eruption time and 95% confidence interval were calculated. The comparison of the curve between the different known risk factors was performed, as exploratory analysis, using the test log-rank. For each result, the median eruption time was calculated (with 95% CI). Statistical analysis was conducted by the statistical software R-3.6.0.

4.RESULTS

The subjects arrived at our observation have been divided and analysed first on the basis of a descriptive analysis. A total of 60 women and 43 men were treated for the disinclusion of their impacted canine. These data confirm that, according to literature, it is more frequent in women than in men (58.2%vs41.8%). The average age of patients is around 18.2 years with a standard deviation (SD) of 5.7 years and a the median(p50) is 16 years. After we proceeded in the description of the characteristics of the canines to have an overall view:

Tab 1 About subjects

Tooth	13	23	33	43	
	54.2%	41.2%	1.5%	3.1%	
Position	V	P	L	Cc	
	29.8%	66.4%	0.8%	3%	
Alpha angle	p25	P50	P75		
	29°	38°	46°		
Sector	1	2	3	4	5
	9.5%	14.3%	30.2%	27.8%	18.2%
Age	>16yr	<16yr			
	65.5%	50.5%			

The most frequent impacted tooth is the 13 with a prevalence of 54.2%, followed by the 23 that is impacted in the 41.2% of the cases analysed. In 66.41% of the subjects the canine was placed palatally and in the 29.8% was located vestibularly. The subjects were almost harmoniously distributed with regard to the 5 sectors of Erikson-kurol with a slight prevalence of the Sector 3 (30.16%). With regard to the alpha angle, for a total of 125 observations, we measured a mean size of 38.7° with a SD of 15.19. Starting from these points, we analysed the success of eruption of the impacted canines and we found that in the 88. 5% we had the eruption. We evaluated also the median time needed for the canine eruption in at least 50% of patients observed.

Tab 2 Analysis Months

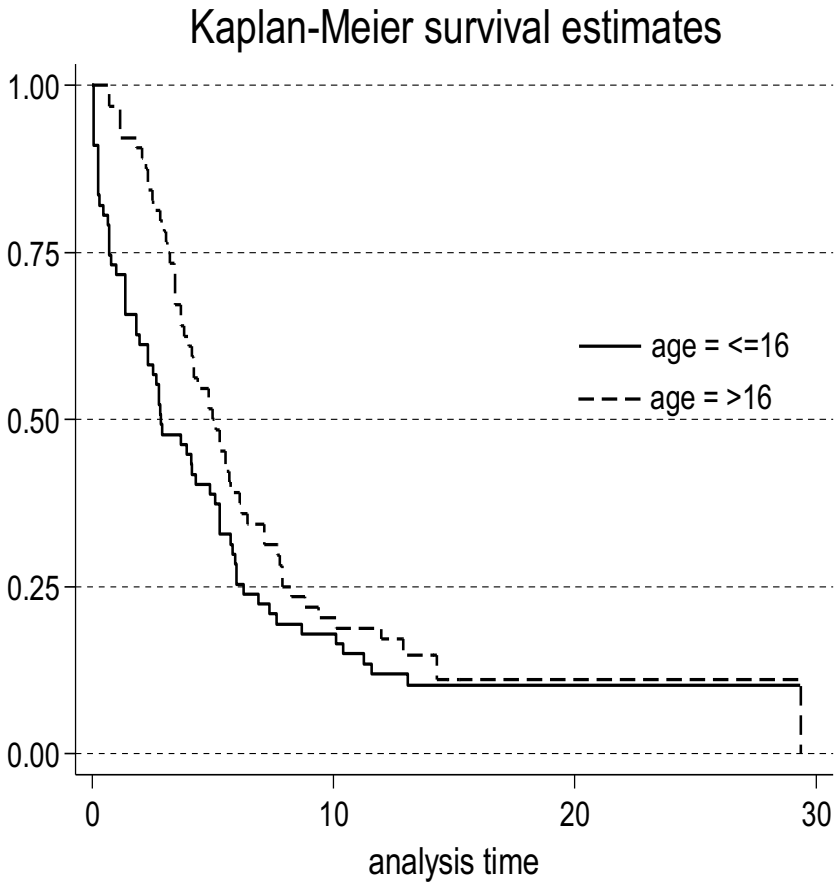
	Number of subjects	50%	Std Error	95% CI
total	131	4.2	.52	3.44 - 5.3

4.2 months, with a 95% of a confidence interval between 3.4 and 5.3, are the time elapsed from the surgery to the eruption, considering all the sample. these data provided an opportunity to ask whether the eruption time could vary depending on whether some factors were taken into account. The first factor examined was the age: we set the target of 16 years and we wanted to evaluate the variation of the eruption time dividing the sample between minors and over 16 years.

Tab 3 Focus Age

Age	Number of subjects	50%	Std Error	95% CI
<16	67	2.85	.72	1.83 – 5.08
>16	64	5	.58	3.8 – 6.09
total	131	4.2	.52	3.44 – 5.27

The time elapsed is 2.85 months, in the population under 16 years, with a 95% of a confidence interval between1.83 and 5.08. In the case of patients aged over 16, the median time elapsed is 5 months, with a 95% of Confidence Interval between 3.8 and 6.09. The **log-rank test** was used to check whether the two curves are statistically significant different and there is no detectable difference, with p=0.07. There is not enough evidence to make us say that the two populations, over 16 years and under 16 years, have a statistically significant difference in terms of eruption time.

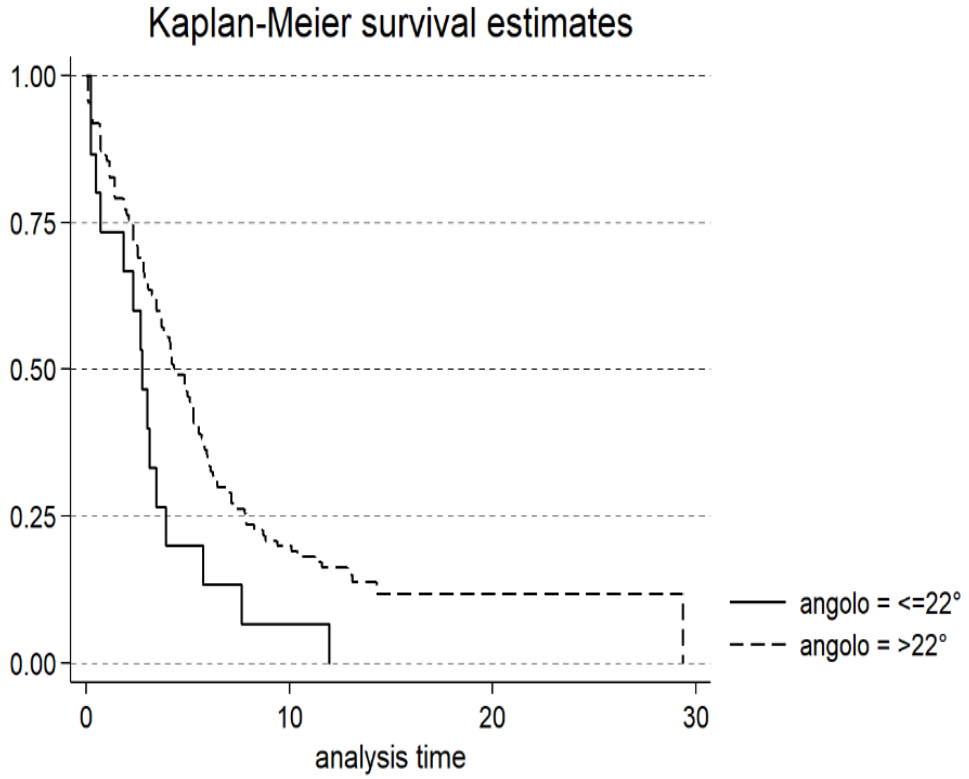


The second factor analysed was the alpha angle. We decided to divide our sample into two groups: one with the angle greater than 22°and the other with an alpha angle lower than 22°.

Tab 4 Focus Angle

Alpha Angle	Number of subjects	50%	Std Error	95% CI
<22°	15	2.75*	.44	0.45 – 3.44
>22°	110	4.29*	.47	3.67 – 5.27
total	125	4.13	.51	3.4 – 5.11

Regarding to this factor, a statistically significant difference was found. The 15 subjects with an alpha angle less than 22° had a median time of eruption of the impacted canine of 2.75 months, considering a confidence interval of 95% from 0.459 to 3.44. The time instead, for those 110 who had an angle greater than 22°, was 4.29 months, with a CI of 95% from 3.67 to 5.27. The **log-rank test** for equality of survivor functions confirms the statistically significant difference, with p=0.015.



The third factor that, for our considerations, could have significantly influenced the eruption time was the sector in which the canine was located and its oral position. We had first of all excluded the Sector 1 and with a median time of Eruption of 4.13 months, with a 95% of confidence interval between 3.4 and 5.11, we have no found statistically significant difference. We have eliminated the vestibular canines and there is not a statistically significant difference in the

median eruption time. We have associated the two factors (Sector1 and vestibular position) and, the median time of eruption is 4.13 months, with a 95%of CI between 2.8 and 5.11. No statistically significant difference is found. We proceeded with the analysis of only the palatal canines and no statistically significant difference in eruption time was found. A comparison was, then, made between the eruption time of canines in sector 2 with those belonging to the macro sector 3-4-5.

Tab 5 Sector 2 Vs Sector 3-4-5

Sectors	Number of subjects	50%	Std. Error	95%CI
1-2	18	2.85	.69	1.83 – 5.67
3-4-5	96	4.09	.40	3.04 – 5.08
total	114	4	.33	3.04 – 4.98

The canines of the sector 2 erupted after 2.85 months, with a 95%of confidence interval from 1.83 to 5.67, unlike those of located in sectors 3,4 or 5 that showed a median eruption time of 4.09 months, with a 95%of CI between 3.04 and 5.08. The **log-rank test**, with a p=0.29, reiterates that there isn't a statistically significant difference. The eruption times of the individual sectors were then merged into a single table and, taking into account the median and the relative confidence intervals for the individual groups, it was concluded that the median eruption time is 4.09 months, with a 95%CI from 3.21 to 5.08.

Tab 6 Focus Sectors

Sector	Number of subjects	50%	Std Error	95%CI
1	12	5.50	2.78	1.37 – 11.96
2	18	2.85	.69	1.83 - 5.67
3	38	2.98	.65	1.37 – 4.88
4	35	5.27	1.04	3.04 – 8.26
5	23	4.13	.54	2.52 – 5.08
total	126	4.09	.51	3.21 – 5.08

Starting from the percentage of success, with the Fisher's test, we have studied the rate of success associated with variation of sector, position, alpha- angle and age.

Tab 7 Fisher's Test

	Sector	Position	Age	Alpha angle
FisherExact	0.243	1.00	0.78	0.215

There are no statistically significant differences in terms of percentage of success but, if we only consider the chart of eruption rate that takes into account the alpha angle, although there is no statistically significant difference according to the Fisher's test, if we combine it with the evaluation previously performed, taking into account only the variation of the alpha angle less than or greater than 22°which was statistically significant, at that point, integrating the two variables, there is a statistically significant difference. In conclusion, we must note that in 103 subjects (78.63%) was used a skeletal anchorage device (TAD).

Tab 9 TADs

TAD	Freq	Percentage
yes	28	21,4
no	103	78,6
total	131	100

5. DISCUSSION

This is an observational study. The impacted canine eruption time has been evaluated in our reference population and, we tried to understand how much and if other clinical and radiographic variables affected the eruption time. After processing these results, we compared them with the data in the literature. The evaluation of the time of eruption represents a novelty in the literature: many studies focused attention on the duration of the treatment (eruption and alignment in the arch) while our primary outcome was to evaluate the time from the surgery to the initial appearance of the canine crown in the oral cavity. The median time of eruption is 4.196 months for all the sample considering 131 canines that we treated with this technique. We have considered the months elapsed from the day of surgery and not the number of visits, in contrast to what was proposed by Becker and Chaushu (Becker & Chaushu, Success Rate and Duration of Orthodontic Treatment for Adult Patients With Palatally Impacted Maxillary Canines , 2003). In order to perform the secondary outcomes, we evaluated the clinical and radiological characteristics of our subjects. In 58.25% of the cases they were women and that more frequently the canines included were 13 and 23, with the prevalence of the 13 on the 23 (54.20%vs44.22%). A total of 87 impacted canines were located palatally in comparison to 39 vestibular canines. The results are confirmed in the data already present in the literature. (Bishara, Impacted Maxillary Canines: A Review, 1992) (Cooke &

HL., 2006) (Ericson & Kurol, 1986) (Grover & Lorton, 1985); (Warford, Grandhi, & Tira, 2003) (Litsas & Acar, 2011). Even if in this study we have considered only the time of eruption and not the time of the entire treatment, we believe that the age is not an important parameter because, considering the "Tab 3", we have not found any statistically significant difference between the eruption times of subjects younger than 16 years and older than 16years. Our conclusion is in accord with was Becker and Chaushu who assessed that age wasn't a fundamental prognostic factor for the impacted canine recovery (Becker & Chaushu, Success Rate and Duration of Orthodontic Treatment for Adult Patients With Palatally Impacted Maxillary Canines , 2003). The panoramic radiographs of the subjects were obtained from different laboratories and this point, according to Zuccati et al (Zuccati & Ghobadlu, 2006), allowed to extend the conclusions to a wider orthodontic population. We found a mean size of the alpha angle of 38.75°and a light prevalence of sector 3-4-5 (Tab 1). The spatial location of the impacted canine was indicated not only by radiographs but also by the orthodontist who treated the case surgically. The variation of the alpha angle between minor and greater than 22° has been shown to be the only variable capable to change the eruption time in a statistically significant way. In the Tab 4, the subjects with an alpha angle <22° had the eruption after a median time of 2.75 months unlike the patients with an alpha angle >22° for which the median time was 4.29 months. This is a statistical significative difference and it is confirmed by Ericson and Kurol on the importance of the alpha angle as prognostic factor (Ericson & Kurol, Early Treatment of Palatally Erupting Maxillary Canines by Extraction of the Primary Canines, 1988). Referring to the sectors (Tab 5), we compared the eruption time of sector 2 with sectors 3-4-5 and, we found no statistically significant differences between the eruption time of sector 2 and the other sectors. This is in contrast with what is suggested by Ericson and Kurol (Ericson & Kurol, Early Treatment of Palatally Erupting

Maxillary Canines by Extraction of the Primary Canines, 1988). The success rate is 88.85%, in fact, a total of 116 out of 131 impacted canines were recovered in the dental arches. It should be said that probably the eruption of some unerupted canines may have been occurred later than the date of the last check-up visit found in the medical record. The type of surgical approach (open or closed) has been chosen only according to the position of the tooth and its depth of inclusion exactly as suggested by literature studies which have shown that there is no difference in prognostic terms of treatment duration when one technique is preferred rather than the other. (Iramaneerat, Cunningham, & Horrcks, 1998). We must emphasize that in no case the "tunnel technique" is applied because we have repeatedly had negative results on the prognosis of impacted canine recovery, like a kind of osteointegration around the tunnellized traction device. This is in disagreement with what is proposed by Crescini in his homonymous technique. (Crescini, Clauser, Giorgetti, & Cortellini, 1994). As suggested by the anchorage table (Tab 9), the Tads have been applied in almost all cases (78.63%vs21.37%) being supporters that skeletal anchor can avoid a number of unlike effects. We can deduce that the use of tads may have benefited in the eruption of the impacted tooth. It is not clear whether the use of TADs can have shortened the eruption time and on what rate. Our conclusions may have been influenced by the small sample size. Some parameters have probably been affected by the reduced number of participants, except for the alpha angle whose variations have affected the eruption time in a statistically significant way.

6. CONCLUSIONS

From the results of this study it can be argued that a decrease in the alpha angle can reduce the time of eruption in statistically significant way. It would be interesting to extend these conclusions to a larger sample of subjects, so as to be able to assess whether the other parameters examined may also have been influenced by a reduced sample size. It was not possible to compare our results with a control group because in our department this is the only approach used and it is for this reason that we firmly believe that it might be useful to extend the study to other centers wich employ different techniques and to compare the results.

7. REFERENCES

- Alessandri Bonetti, G., Incerti Parenti, S., Zanarini, M., & Marini, I. (2010). Double vs Single Primary Teeth Extraction Approach as Prevention of Permanent Maxillary Canines Ectopic Eruption. *Pediatr Dent . ,* 407-412.
- Alqerban, Jacobs, Lambrechts, Loozen, & Willems. (2009). Root Resorption of the Maxillary Lateral Incisor Caused by Impacted Canine: A Literature Review. *Clin Oral Investig .,* 247-255.
- Baccetti, T., Leonardi, M., & Armi, P. (2008). A Randomized Clinical Study of Two Interceptive Approaches to Palatally Displaced Canines . *Eur J Orthod . .*
- Beadnell, S. (2012). Management of the Impacted Canine. *Oral & Maxillofacial Surgery*.
- Becker, A. (2007). *TheOrthodonticTreatmentOfImpactedTeeth2ndEd.* Jerusalem.
- Becker, A. (2010). Extreme Tooth Impaction and Its Resolution. *Seminars in Orthodontics*, 222-233.
- Becker, A., & Chaushu, S. (2003). Success Rate and Duration of Orthodontic Treatment for Adult Patients With Palatally Impacted Maxillary Canines . *Am J Orthod Dentofacial Orthop* , 509-514.
- Becker, A., & Chaushu, S. (2013). Palatally Impacted Canines: The Case for Closed Surgical Exposure and Immediate Orthodontic Traction. *Am J Orthod Dentofacial Orthop .,* 451-459.
- Becker, A., & Chaushu, S. (2015). Etiology of maxillary canine impaction: A review. *American Journal of Orthodontics and Dentofacial Orthopedic*, 557-567.
- Becker, A., & Chaushu, S. (2015). Surgical Treatment of Impacted Canines: What the Orthodontist Would Like the Surgeon to Know . *Oral Maxillofac Surg Clin North Am .,* 449-458.

- Becker, A., Abramovitz, I., & Chaushu, S. (2013). Failure of Treatment of Impacted Canines Associated With Invasive Cervical Root Resorption . *Angle Orthod .*, 870-876.
- Becker, A., Brin, I., Ben-Bassat, Y., Zilberman, Y., & Chaushu, S. (2002). Closed-eruption Surgical Technique for Impacted Maxillary Incisors: A Postorthodontic Periodontal Evaluation. *Am J Orthod Dentofacial Orthop .*, 9-14.
- Becker, A., Chaushu, G., & Chaushu, S. (2010). Analysis of Failure in the Treatment of Impacted Maxillary Canines. *Am J Orthod Dentofacial Orthop .*, 743-754.
- Becker, A., Chaushu, S., & Casap-Caspi, N. (2010). Cone-beam Computed Tomography and the Orthosurgical Management of Impacted Teeth. *J Am Dent Assoc .*
- Becker, A., Sharabi, S., & Chaushu, S. (2002). Dental Morphologic Characteristics of Normal Versus Delayed Developing Dentitions With Palatally Displaced Canines. *Am J Orthod Dentofacial Orthop .*, 339-346.
- Becker, A., Zilberman, Y., & Tsur, B. (1984). Root Length of Lateral Incisors Adjacent to Palatally-Displaced Maxillary Cuspids. *Angle Orthod .*, 218-225.
- Bedoya, M., & Park, J. (2009). A Review of the Diagnosis and Management of Impacted Maxillary Canines. *J Am Dent Assoc .*
- Bergsrom, K. (1976). Orthopantomography of School Children. *Tandlakartidningen .*, 1201-1207.
- Bishara, S. (1992). Impacted Maxillary Canines: A Review. *am J Orthod Dentofacial Orthop .*, 159-171.
- Bishara, S. (1998). Clinical Management of Impacted Maxillary Canines. *Semin Orthod .*, 87-98.
- Bishara, S., Kommer, D., McNeil, M., Montagano, L., Osterle, L., & Youngquist, H. (1976). Management of Impacted Canines. *Am J Orthod .*
- Bonetti, G., Zanarini, M. I., Marini, I., & Gatto, M. (2011). Preventive Treatment of Ectopically Erupting Maxillary Permanent Canines by Extraction of Deciduous Canines and First Molars: A Randomized Clinical Trial. *Am J Orthod Dentofacial Orthop .*, 316-323.

- Brin, I., Becker, A., & Shalhav, M. (1986). Position of the Maxillary Permanent Canine in Relation to Anomalous or Missing Lateral Incisors: A Population Study. *Eur J Orthod . .*
- Broadbent, B. (1941). Ontogenic Development of Occlusion.
- Buchner, H. (1936). Root resorption caused by ectopic eruption of maxillary cuspid.
- Carano, A., & Melsen, B. (2005). Implants in Orthodontics. Interview. *Prog Orthod .*, 62-69.
- Celikoglu, M., Kamak, H., & Oktay, H. (2010). Investigation of Transmigrated and Impacted Maxillary and Mandibular Canine Teeth in an Orthodontic Patient Population. *J Oral Maxillofac Surg .*, 1001-1006.
- Chaushu, S., Chaushu, G., & Becker, A. (2004). The Role of Digital Volume Tomography in the Imaging of Impacted Teeth. *World J Orthod . ,* 120-132.
- Cooke, J., & HL., W. (2006). Canine Impactions: Incidence and Management. *Int J Periodontics Restorative Dent*, 483-491.
- Cope, J. (2005). Temporary anchorage devices in orthodontics: A paradigm shift. *Seminars in Orthodontics*, 3-9.
- Coulter, J., & Richardson, A. (1997). Normal Eruption of the Maxillary Canine Quantified in Three Dimensions . *Eur J Orthod .*, 171-183.
- Counihan, & Hegarty. (1997). In Defence of Transplants: A Case Report. *Dent Update ,* 138-142.
- Cozza, P., Mucedero, M., Ricchiuti, M., & Baccetti, T. (2010). Prevalence Rate and Dentoskeletal Features Associated With Buccally Displaced Maxillary Canines. *Eur J Orthod .*, 305-309.
- Crescini, A., Clauser, C., Giorgetti, R., & Cortellini, P. P. (1994). Tunnel Traction of Infraosseous Impacted Maxillary Canines. A Three-Year Periodontal Follow-Up. *Am J Orthod Dentofacial Orthop . ,* 61-72.
- Crescini, A., Nieri, M., Buti, J., Baccetti, T., & Pini Prato, G. (2007). Orthodontic and Periodontal Outcomes of Treated Impacted Maxillary Canines. *Angle Orthod . ,* 571-577.

- Dalessandri, D., Parrini, S., Rubiano, R., Gallone, D., & Migliorati, M. (2017). Impacted and Transmigrant Mandibular Canines Incidence, Aetiology, and Treatment: A Systematic Review. *Eur J Orthod .*, 161-169.
- Daskalogiannakis, J. (2000). *Glossary of orthodontic terms.* Michigan: Quintessence Books.
- Deguchi, T., Takano-Yamamoto, T., Kanomi, R., Hartsfield, J. J., Roberts, W., & Garetto, L. (2003). The Use of Small Titanium Screws for Orthodontic Anchorage. *J Dent Res .*, 377-381.
- Ericson, S., & Kurol, J. (1986). Radiographic Assessment of Maxillary Canine Eruption in Children With Clinical Signs of Eruption Disturbance. *Eur J Orthod*, 133-140.
- Ericson, S., & Kurol, J. (1988). Early Treatment of Palatally Erupting Maxillary Canines by Extraction of the Primary Canines. *Eur J Orthod .*, 283-295.
- Fagade, O., Gillbe, G., & Wastell, D. (1988). Radiographic Pattern of Root Resorption in Autotransplanted Maxillary Canines . *J Dent .*
- Garib, D., Alencar, B., Lauris, J., & Baccetti, T. (2010). Agenesis of Maxillary Lateral Incisors and Associated Dental Anomalies. *Am J Orthod Dentofacial Orthop .*
- Grover, P., & Lorton, L. (1985). The Incidence of Unerupted Permanent Teeth and Related Clinical Cases. *Oral Surg Oral Med Oral Pathol .*, 420-425.
- Hägg, & Taranger. (1986). Timing of Tooth Emergence. A Prospective Longitudinal Study of Swedish Urban Children From Birth to 18 Years. *Swed Dent J .*
- Heaney, T., & Atherton, J. (1976). Periodontal Problems Associated With the Surgical Exposure of Unerupted Teeth. *Br J Orthod .*, 79-84.
- Heravi, F., Shafaee, H., Forouzanfar, A., Zarch, S. H., & Merati, M. (2016). The Effect of Canine Disimpaction Performed With Temporary Anchorage Devices (TADs) Before Comprehensive Orthodontic Treatment to Avoid Root Resorption of Adjacent Teeth. *tal Press J Orthod .*, 65-72.
- Huber, K., Suri, L., & Taneja, P. (2008). Eruption Disturbances of the Maxillary Incisors: A Literature Review. *Clin Pediatr Dent .*, 221-230.

- Hunter, S. (1981). The Radiographic Assessment of the Unerupted Maxillary Canine. *Br Dent J . ,* 151-155.
- Hurme, V. (1949). Ranges of Normalcy in the Eruption of Permanent Teeth. *J Dent Child .*
- Iramaneerat, S., Cunningham, S., & Horrcks, E. (1998). The Effect of Two Alternative Methods of Canine Exposure Upon Subsequent Duration of Orthodontic Treatment. *Int J Paediatr Dent .*, 123-129.
- Jacoby, H. (1983). The Etiology of Maxillary Canine Impactions . *Am J Orthod .*, 125-132.
- Johnston, W. (1969). Treatment of Palatally Impacted Canine Teeth. *Am J Orthod . ,* 589-596.
- Kettle, M. (1957). Treatment of unerupted maxillary canine.
- Kocsis, A., & Seres, L. (2012). Orthodontic Screws to Extrude Impacted Maxillary Canines. *J Orofac Orthop .*
- Kokich, V. (2004). Surgical and Orthodontic Management of Impacted Maxillary Canines. *Am J Orthod Dentofacial Orthop .*, 278-283.
- Kokich, V. (2004). Surgical and Orthodontic Management of Impacted Maxillary Canines. *Am J Orthod Dentofacial Orthop .*, 278-283.
- Kokich, V., & Mathews, D. (1993). Surgical and Orthodontic Management of Impacted Teeth. *Dent Clin North Am . ,* 181-204.
- Kokich, V., & Mathews, D. (2001). *Impacted teeth: surgical and orthodontic considerations.* Ann Arbor .
- Kokich, V., & Mathews, D. (2013). Palatally Impacted Canines: The Case for Preorthodontic Uncovering and Autonomous Eruption. *Am J Orthod Dentofacial Orthop . ,* 450-458.
- Kornhauser, S., Abed, Y., & Harari, D. (1996). The Resolution of Palatally Impacted Canines Using Palatal-Occlusal Force From a Buccal Auxiliary. *Am J Orthod Dentofacial Orthop*, 528-534.
- Leonardi, M., Armi, P., Franchi, L., & Baccetti, T. (2004). Two Interceptive Approaches to Palatally Displaced Canines: A Prospective Longitudinal Study. *Angle Orthod .*, 581-586.

- Lind, V. (1977). Orthodontic Care VII. Problems of Eruption of Upper Canine. *Tandlakartidningen . ,* 1066-1075.
- Lindauer, S., Rubenstein, L., Hang, W., Andersen, W., & Isaacson, R. (1992). Canine Impaction Identified Early With Panoramic Radiographs. *J Am Dent Assoc .*
- Liou, E., Pai, B., & Lin, J. (2004). Do Miniscrews Remain Stationary Under Orthodontic Forces? *Am J Orthod Dentofacial Orthop .*, 42-47.
- Litsas, G., & Acar, A. (2011). A Review of Early Displaced Maxillary Canines: Etiology, Diagnosis and Interceptive Treatment . *Open Dent J .*, 39-47.
- Mathews, D., & Kokich, V. (2013). Palatally Impacted Canines: The Case for Preorthodontic Uncovering and Autonomous Eruption. *Am J Orthod Dentofacial Orthop .*, 450-458.
- McConnell, T., Hoffman, D., Forbes, D., Janzen, E., & Weintraub, N. (1996). Maxillary Canine Impaction in Patients With Transverse Maxillary Deficiency. *ASDC J Dent Child .*, 190-195.
- Mcconnell, T., Hoffman, D., Forbes, D., Jensen, E., & Wientraub, N. (1996). MaxillaryCanine Impaction in Patients With Transverse Maxillary Deficiency. *Journal of Dentistry for Children* , 190-195.
- Melsen, B. (2005). Mini-implants: Where Are We? . *J Clin Orthod .*, 539-547.
- Melsen, B., & Costa, A. (2000). Immediate Loading of Implants Used for Orthodontic Anchorage. *Clin Orthod Res .*, 23-28.
- Melsen, B., & Garbo, D. (1999). Treating the "impossible case" with the use of the Aarhus Anchorage System,.
- Moorrees, C., Fanning, E., & Hunt, E. (1963). FORMATION AND RESORPTION OF THREE DECIDUOUS TEETH IN CHILDREN. *Am J Phys Anthropol .*
- Moss, J., 1972, &). (1972). The Unerupted Canine. *Dent Pract Dent Rec .*, 241-248.
- Moyers, R., van der Linden, F., Riolo, M., & McNamara, J. (1976). *Standards of Human Oc- clusal Development. Monograph 5, Craniofacial Growth Series. .* Ann Arbor.

- Mupparapu. (2002). Patterns of intra-osseous transmigration and ectopic eruption of mandibular canines: Review of literature and report of nine additional cases. *Dentomaxillofacial Radiology*, 355-360.
- Nanda, S. (1983). *Developmental Basis of Occlusion and Malocclusion.*
- Naoumova, J., Alfaro, G., & Peck, S. (2018). Space Conditions, Palatal Vault Height, and Tooth Size in Patients With and Without Palatally Displaced Canines: A Prospective Cohort Study . *Angle Orthod . *, 726-732.
- Naoumova, J., Rahbar, E., & Hansen, K. (2018). Glass-ionomer Open Exposure (GOPEX) Versus Closed Exposure of Palatally Impacted Canines: A Retrospective Study of Treatment Outcome and Orthodontists' Preferences. *Eur J Orthod . *, 617-625.
- Ngan, P., Hornbrook, R., & Weaver, B. (2005). Early Timely Management of Ectopically Erupting Maxillary Canines. *Seminars in Orthodontics*, 152-163.
- Nolla, C. (1960). The development of permanent teeth. . *Journal of Dentistry for Children*.
- Olive, R. (2002). Orthodontic Treatment of Palatally Impacted Maxillary Canines. *Aust Orthod J* , 64-70.
- Olive, R. (2005). Factors Influencing the Non-Surgical Eruption of Palatally Impacted Canines. *Aust Orthod J .*, 95-101.
- Papadopoulos, M., & Tarawneh, F. (2007). The Use of Miniscrew Implants for Temporary Skeletal Anchorage in Orthodontics: A Comprehensive Review. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod . .*
- Park, H., Kwon, O., & Sung, J. (2004). Micro-implant Anchorage for Forced Eruption of Impacted Canines. *J Clin Orthod .*, 297-302.
- Parkin, N. (2012). No Difference in Surgical Outcomes Between Open and Closed Exposure of Palatally Displaced Maxillary Canines. *J Oral Maxillofac Surg* .
- Parkin, N., Almutairi, S., & Benson, P. (2019). Surgical Exposure and Orthodontic Alignment of Palatally Displaced Canines: Can We Shorten Treatment Time? *J Orthod .*, 54-59.

- Peck, S., Peck, L., & Kataja, M. (1994). The Palatally Displaced Canine as a Dental Anomaly of Genetic Origin. *Angle Orthod .*, 249-256.
- Pilon, J., Kuijpers-Jagtman, A., & Maltha, J. (1996). Magnitude of Orthodontic Forces and Rate of Bodily Tooth Movement. An Experimental Study . *Am J Orthod Dentofacial Orthop .*, 16-23.
- Pirinen, S., Arte, S., & Apajalahti, S. (1996). Palatal Displacement of Canine Is Genetic and Related to Congenital Absence of Teeth. *J Dent Res .*
- Proffit, W., Fields, H., & Sarver, D. (2007). *Contemporary orthodontics.*
- Raghoebar, G., Boering, G., Vissink, A., & Stegenga, B. (1991). Secondary Retention in the Primary Dentition . *ASDC J Dent Child .*, 17-22.
- Sajnani, A., & King, N. (2012). Early prediction of maxillary canine impaction from panoramic radiographs. *American Journal of Orthodontics and Dentofacial Orthopedics*.
- Schour, I., & Massler, M. (1941). Updating of the Dentition Tables of I. Schour and M. Massler of 1941. *Fortschr Kieferorthop .*
- Shapira, & Kuftinec. (2001). A Unique Treatment Approach for Maxillary Canine-Lateral Incisor Transposition. *Am J Orthod Dentofacial Orthop .*, 540-545.
- Suri, L., Gagari, E., & Vastardis, H. (2004). Delayed Tooth Eruption: Pathogenesis, Diagnosis, and Treatment. A Literature Review. *Am J Orthod Dentofacial Orthop* .
- Taylor, R. (1998). Eruptive abnormalities in orthodontic treatment. *Seminars in Orthodontics*, 79-86.
- Van der Linden, F. (1983). *Development of the dentition.*
- Vanarsdall, R., & Corn, H. (1977). Soft-tissue Management of Labially Positioned Unerupted Teeth. July 1977. *Am J Orthod Dentofacial Orthop .*, 284-293.
- Vermette, M., Kokich, V., & Kennedy, D. (1995). Uncovering Labially Impacted Teeth: Apically Positioned Flap and Closed-Eruption Techniques. *Angle Orthod .*, 23-32.

- Warford, J., Grandhi, R., & Tira, D. (2003). Prediction of Maxillary Canine Impaction Using Sectors and Angular Measurement. *Am J Orthod Dentofacial Orthop .*, 651-655.
- Weinstein, S., Haak, D., Morris, L. S., & Attaway, H. (1963). One equilibrium theory of tooth position. *Angle Orthod*.
- Zuccati, G., & Ghobadlu, J. N. (2006). Factors Associated With the Duration of Forced Eruption of Impacted Maxillary Canines: A Retrospective Study. *Am J Orthod Dentofacial Orthop .*, 349-356.

8. PUBLICATIONS:

Perrotta S, Lo Giudice G, Bocchino T, Califano L, Valletta R. Orthodontics First in Hemimandibular Hyperplasia. "Mind the Gap". Int J Environ Res Public Health. 2020; 28;17:7087

Perrotta S, Bucci R, SimeonV, Martina S, Michelotti A, Valletta R
Prevalence of malocclusion, oral parafunctions and temporomandibular disorders-pain in italian school children: an epidemiological study. J Oral Rehabilitation 2019; 46:611-616

Perrotta S, Bocchino T, D'Antò V, Michelotti A, Valletta R.
Pseudo Hemifacial Microsomia With Condylar-Coronoid Collapse: New Therapeutic Approach in Growing Patients. 5. J Craniofac Surg. 2020;31:2128-2131

Dell'Aversana Orabona G, Perrotta S, Lo Giudice G, Bocchino T, Valletta R, Abbate V, Califano L. Dentoalveolar Fractures: New Orthodontic Protocol Proposal and Pilot Study. J Craniofac Surg. 2020 31:755-760.

Perrotta S, Bocchino T, D'Antò V, Michelotti A, Valletta R.

Pseudo Hemifacial Microsomia With Condylar-Coronoid Collapse: New Therapeutic Approach in Growing Patients. 5. J Craniofac Surg. 2020;31:2128-2131

Perrotta S, Valletta R, Sorrentino R, Zarone F
"Interdisciplinary full digital restorative treatment of a young patient with severe open bite and amelogenesis imperfecta: a case report".
Journal of Osseointegration, Gen 2021 (Accepted)

Cioffi I, Michelotti A, Perrotta S, Chiodini P, Ohrbach R.
“Effect of somatosensory amplification and trait anxiety on experimentally induced orthodontic pain.Eur. J Oral Sci 2016; 124:127-134

Cioffi I, Perrotta S, Ammendola L, Cimino R, Vollaro S, Paduano S, Michelotti A. “Social impairment of individuals suffering from different types of chronic orofacial pain”. Progress in Orthodontics 2014; 15:27