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EVALUATION OF PERIODONTAL STATUS OF ECTOPIC CANINES AFTER ORTHODONTIC TREATMENT

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Bu tez çalışmasının kendi çalışmam olduğunu, tezin planlanmasından yazımına kadar bütün aşamalarda etik dışı davranışımın olmadığını, bu tezdeki bütün bilgileri akademik ve etik kurallar içinde elde ettiğimi, bu tez çalışmasıyla elde edilmeyen bütün bilgi ve yorumlara kaynak gösterdiğimi ve bu kaynakları da kaynaklar listesine aldığımı, yine bu tezin çalışılması ve yazımı sırasında patent ve telif haklarını ihlal edici bir davranışımın olmadığı beyan ederim.

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II) CONTENTS

III) ABBREVIATIONS

AGW : Attached Gingival Width
BL : Bone Level
CA : Close Approach
CEJ : Cemento Enamel Junction
CL : Crown Length
EPTS : Electric Pulp Testing Score
Et al : And others
GBI : Gingival Bleeding Index
GL : Gingival Level
mm : Millimeter
OA : Open Approach
PD : Pocket Depth
PI : Plaque Index
RL : Root Length

1. SUMMARY

The purpose of this study was to evaluate the periodontal health of palatally impacted or buccaly ectopic maxillary canines after their alignment in dental arch.

From the archive files of the Department of Orthodontics in the Dental Faculty of Marmara University and Dental Faculty of Yeditepe University, 15 patients were identified who had unilateral palatally impacted canines and 15 patients who had unilateral buccally ectopic canines at the beginning of their orthodontic treatment. All of these patients had completed their fixed orthodontic treatment.

In the first group of patients palatally impacted canines had been exposed using a close approach (CA) technique with minimal bone removal in the Department of Dental Surgery of Marmara University and Yeditepe University. Attachments had been bonded to the impacted canines at the time of surgical exposure.

In the second group of patients who had buccaly ectopic maxillary canines, orthodontic treatment for alignment of these teeth were completed by conventional orthodontic techniques.

The collection of clinical data was made by recalling the patients in both groups to the clinic, to evaluate their periodontal status clinically and radiographically. In both groups, the contralateral normally placed canines served as control.

As a result;

1) Palatally impacted canines had greater pocket depths, higher gingival levels, higher electric pulp testing scores and reduced bone levels compared to their contralaterals.

2) Buccaly ectopic canines had increased plaque index, increased gingival bleeding index, greater pocket depths, reduced attached gingival width, higher gingival levels, increased clinical crown lengths and higher electric pulp testing scores compared to their contralaterals.

3) Buccaly ectopic canines had lower electric pulp testing scores and higher bone levels compared to palatally impacted canines.

Keywords: Palatally impacted canine, buccaly ectopic canine, closed approach, periodontal health, open approach.

2. ÖZET

EKTOPİK POZİSYONDA BULUNAN ÜST KANİNLERİN ORTODONTİK TEDAVİ SONRASINDA PERİODONTAL SAĞLIKLARININ DEĞERLENDİRİLMESİ

Çalışmamızın amacı palatinalde gömük veya bukkalde ektopik pozisyonda bulunan kaninlerin ortodontik tedavileri sonrasında periodontal dokularının sağlıklarını değerlendirmektir.

Marmara Üniversitesi Diş Hekimliği Fakültesi Ortodonti Anabilim Dalı ve Yeditepe Üniversitesi Diş Hekimliği Fakültesi Ortodonti Anabilim Dalı arşivlerindeki hastalardan, tedavi başında tek taraflı palatinalde gömük kanini olan 15 hasta ve yine tedavi başında tek taraflı bukkalde ektopik pozisyonda kanini olan 15 hasta yani toplam 30 hasta belirlenmiştir. Bütün bu hastaların sabit ortodontik tedavileri bitmiştir.

Birinci grup hastaların palatinaldeki gömük kaninleri Marmara Üniversitesi ve Yeditepe Üniversitesi Cerrahi Anabilim Dalı'nda kapalı teknikle ve çok az kemik kaldırılarak açığa çıkartılmıştır. Ataşmanlar gömük kaninlere cerrahi işlem sırasında yapıştırılmıştır.

İkinci grup hastalarda yani üst kaninin bukkalde ektopik pozisyonda olduğu vakalarda, tedavi ile bu dişlerin hizalanması geleneksel ortodontik tekniklerle yapılmıştır.

Klinik verilerin toplanması için her iki gruptaki hastalar kliniğe tekrar çağrılmış ve periodontal durumları klinik ve radyografik olarak değerlendirilmiştir. Her iki grupta da diğer taraftaki normal yerinde bulunan kanin kontrol diş olarak hizmet etmiştir.

Sonuç olarak,

1) Palatinal'de gömük kaninlerin kontrol grubu ile kıyaslandıklarında cep derinlikleri, dişeti seviyeleri, vitalite değerleri artmış ve kemik seviyeleri azalmıştır.

2) Bukkal'deki ektopik kaninlerin kontrol grubu ile kıyaslandıklarında plak indeksleri, dişeti kanama indeksleri, cep derinlikleri, dişeti seviyeleri, klinik kron boyları, vitalite değerleri artmış; dişeti genişlikleri azalmıştır.

3) Bukkal ektopik kaninler, palatinal gömük kaninlerle kıyaslandıklarında vitalite değerleri azalmış ve kemik seviyeleri artmıştır.

Anahtar kelimeler: Palatinalde gömük kanin, bukkalde ektopik kanin, kapalı

teknik, periodontal sağlık, açık teknik.

3. INTRODUCTION AND AIMS

The prevalence of impacted maxillary canines is 0.9-2.2% and they are often treated with orthodontic eruption, but periodontal problems associated with the process can evade detection. Profound destruction of the periodontium of an impacted tooth or adjacent teeth can occur. Periodontal problems can be encountered during orthodontic eruption of buccaly ectopic canines, as well.

The maxillary permanent canine usually is the last tooth to erupt and its normal path of eruption is slightly buccal to the line of the arch. In its early stages of descent this tooth is normally palpable high in the buccal sulcus as early as the age of 8 to 9 years, and it finally erupts in a more buccal position than its recently shed deciduous predecessor. Therefore, in the presence of crowding this buccal eruption path becomes exaggerated because of lack of space and the tooth erupts more buccaly and higher in the alveolar process, either through the attached gingiva at a higher level than is normal or into the alveolar mucosa.

Also there are many causes of palatal displacement, such as long path of eruption, crowding, non-resorption of the root of the deciduous canine and trauma.

As we know either an open (OA) or a closed (CA) surgical-exposure techniques can be used to uncover the crown of an impacted tooth and to place an orthodontic attachment. The advantages of the OA include the orthodontist's ability to observe the impacted tooth as it is moved and faster eruption, but this method is associated with multiple periodontal concerns, including gingival recession, bone loss, decreased width of keratinized gingiva, delayed periodontal healing and gingival inflamation.

To improve the possibility of erupting an impacted canine or hasten its eruption, some orthodontists recommend extensive removal of bone around the tooth's crown and channeling bone from the crown to the alveolar crest. Impacted canines exposed with this tecnique demonstrated significantly more bone loss after treatment specially in buccaly erupted canine cases. Also, extensive bone removal that might inadvertently involve the cementoenamel junction (CEJ) should be avoided. Patients treated with more extensive bone removal such that the CEJ was fully exposed had on average 5.4% less bony support (measured from the canine apex to the crest of the interseptal bone) than those patients treated with less extensive bone removal.

Ectopic canines requiring torquing root movements had 4% less bony support than those aligned by tipping or extrusive movements. So the amount of surgical bone removal and the orthodontic mechanics used may be important factors influencing long-term periodontal health. The periodontal condition of treating impacted canines is almost always affected from these 2 procedures used.

It seems that less damaging effects on the periodontium should anticipated when using the closed-surgical exposure techniques, which involve raising of a surgical flap, bonding of an attachment and finally resuturing of the flap to its original position.

Also one of our variables is electric pulp testing score, this is not related with periodontal health but orthodontic treatment itself carries a risk of tooth morbidity. During the treatment of impacted canines both surgical and orthodontic procedures were used. So tooth vitality could be affected from these procedures. In order to understand this we also measured the electric pulp testing scores of palatally impacted and buccaly ectopic canines and the contralateral ones and compared them.

In our study we aimed to assess the periodontal status of finished palatally impacted canine cases which were exposed with closed-surgical approach and buccaly ectopic canines which were treated with conventional orthodontic techniques and compare them with the contralateral canines which served as control teeth. Also we compared the periodontal health of these palatally impacted and buccaly ectopic canines with each other. By determining to which extent we had been successful in preserving the periodontal health of our treated ectopic canine cases, we will have a chance to evaluate our treatment strategies and consider some modifications if needed.

4. LITERATURE REVIEW

4.1 IMPACTED TEETH

4.1.1 Causes

Under normal circumstances a tooth erupts with a developing root and with approximately three-quarters of its final root length. The normal eruption process of a tooth must be presumed to have been impeded by one of several aetiologic possibilities. These include such factors as a failure of resorption of the roots of a deciduous tooth, an abnormal eruptive path, a supernumerary tooth, dental crowding or a disturbance in the eruption mechanism of the tooth. However, obstruction may also result from a thickened post-extraction or post trauma repair of the mucosa (75, 86).

The etiologic factors of maxillary canine impaction are rarely mentioned in the professional literature. Most of the authors repeat the same references. Moyers writes: "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 then seems to be deflected to a more vertical position; however, it often erupts into the oral cavity with a marked mesial inclination". Describing in general the impacted teeth, Moyers remarked: "Although there are hereditary patterns leading to impacted teeth, the etiologic factors of most concern are prolonged retention of primary teeth, localized pathologic lesions and shortening of the length of the arch .... This tooth (the maxillary cuspid) may be simply impacted, as sometimes happens when the primary cuspid fails to resorb, or it may be impacted ectopically" (76).

Bishara and associates summarized Moyer's theory that impaction is caused by (14):

1. Primary Causes:

A. Rate of root resorption of deciduous teeth.

B. Trauma of the deciduous tooth bud.

C. Disturbances in tooth eruption sequence.

D. Availability of space in the arch.

E. Rotation of tooth buds.

F. Premature root closure.

G. Canine eruption into the cleft area in persons with cleft palate.

2. Secondary Causes:

A. Abnormal muscle pressure.

B. Febrile diseases.

C. Endocrine disturbances.

D. Vitamin D deficiency.

4.1.2 Prevalence

Moyers (76) noted that any tooth can be impacted, but the teeth most frequently involved are the mandibular first molar, the maxillary canine, the mandibular and maxillary second premolars, and the maxillary central incisor, in that order.

The prevalence of impacted maxillary canines is 0.9–2.2% and, in most cases, the impacted canines are ectopically positioned (29). Eighty-five percent are palatal to the dental arch (36). However, in a recent study on 156 ectopically positioned canines, 50% were in a palatal or distopalatal position, 39% in a buccal or distobuccal position, and 11% apical to the adjacent incisor or between the roots of the central and lateral incisors (37).

In cases of impacted maxillary canines, resorption of the central or lateral incisor roots can be expected to be present in almost 50% of the cases and to be three times as common in girls as in boys (37, 38, 39). Computed tomographic scanning is superior to other radiographic methods to examine bone destruction as well as resorption or small lesions on tooth roots (35, 36, 37, 38, 39). About 50% more resorptions are detected with computerized tomography (CT) compared with conventional radiographic methods that provide intraoral and panoramic radiographs (36, 37, 39). CT scanning is also valuable in determining the exact position of malposed maxillary canines (37).

4.2 GENERAL PRINCIPLES RELATED TO THE DIAGNOSIS AND TREATMENT OF IMPACTED CANINES

4.2.1 When is a Tooth Considered to be Impacted?

The diagnosis of canine impaction is based on both clinical and radiographic examinations.

Clinical evaluation: It has been suggested that the following clinical signs might be indicative of canine impaction: (a) delayed eruption of the permanent canine or prolonged retention of the deciduous canine beyond 14 to 15 years of age, (b) absence of a normal labial canine bulge, in other words, either inability to locate canine position through intraoral palpation of the alveolar process or the presence of an asymmetry in the canine bulge noted during alveolar palpation, (c) presence of a palatal bulge, and (d) delayed eruption, distal tipping, or migration (splaying) of the lateral incisor (17).

Early detection of impacted canines includes clinical examination of the permanent lateral incisors. Their abnormal position or angulation could indicate a deflected canine, which could potentially become impacted. Severely distally tipped crowns of lateral incisors might be pressured by the crown of a mesially displaced canine against the distal aspect of the lateral incisor root. A labially inclined lateral incisor could be the result of a displaced canine lying on the labial aspect of the lateral incisor root. Excessive or unusual mobility of the maxillary permanent lateral incisor could be the result of root resorption caused by a displaced canine (85).

According to Ericson and Kurol (35), the absence of the "canine bulge" at earlier ages should not be considered as indicative of canine impaction. In their evaluation of 505 school children between 10 and 12 years of age, they found that 29% of the children had nonpalpable canines at 10 years, but only 5% at 11 years, whereas at later ages only 3% had nonpalpable canines.

Radiographic evaluation: For an accurate diagnosis the clinical examination should be supplemented with a radiographic evaluation (17).

Although various radiographic exposures, including occlusal films, panoramic views, and lateral cephalograms, can help in evaluating the position of the canines, in most cases periapical films are uniquely reliable for that purpose.

1. Periapical films: A single periapical film provides the clinician with a two-

dimensional representation of the dentition. In other words, it would relate the canine to the neighboring teeth both mesiodistally and superoinferiorly. To evaluate the position of the canine buccolingually, a second periapical film should be obtained by one of the following methods.

a. Tube-shift technique or Clark's rule: Two periapical films are taken of the same area, with the horizontal angulation of the cone changed when the second film is taken. If the object in question moves in the same direction as the cone, it is lingually positioned. If the object moves in the opposite direction, it is situated closer to the source of radiation and is therefore buccally located.

b. Buccal-object rule: If the vertical angulation of the cone is changed by approximately 20° in two successive periapical films, the buccal object will move in the direction opposite the source of radiation. On the other hand, the lingual object will move in the same direction as the source of radiation. The basic principle of this technique deals with the foreshortening and elongation of the images of the films.

2. Occlusal films: They also help to determine the buccolingual position of the impacted canine in conjunction with the periapical films, provided that the image of the impacted canine is not superimposed on the other teeth.

3. Extraoral films: a) Frontal and lateral cephalograms: They can sometimes aid in the determination of the position of the impacted canine, particularly its relationship to other facial structures (e.g., the maxillary sinus and the floor of the nose). **b) Panoramic films:** They are also used to localize impacted teeth in all three planes of space, much the same as with two periapical films in the tube-shift method, with the understanding that the source of radiation comes from behind the patient; thus the movements are reversed for position.

The proper localization of the impacted tooth plays a crucial role in determining the feasibility of, as well as the proper access for, the surgical approach, and the proper direction for the application of orthodontic forces (17).

According to Ericson and Kurol (36), with the use of periapical films the clinician is able to evaluate the position of the canine with sufficient accuracy in 92% of the cases. However, in only 37% of the cases were they able to project the lateral incisor image away from that of the canine.

The evaluation of the condition of the lateral incisor root is of great importance

to the clinician since 80% of the teeth resorbed by the ectopically erupting canines were found to be lateral incisors. Ericson and Kurol (36), estimated that 0.7% of the children in the 10 to 13 year age group have resorbed permanent incisors because of ectopic eruption of the maxillary canines. With a more elaborate radiographic technique, polytomography, Ericson and Kurol found the number of teeth that were diagnosed as resorbed almost doubled. Of concern is that in half of the teeth that showed resorption, the lesion extended into the pulp. Furthermore, 50% of the children had either labial or lingual resorption that would escape detection in routine periapical radiographic evaluations (33).

4.2.2 Impacted Canines and Local Space Loss

A time exists between the performance of a surgical procedure to remove the cause of an impaction and the full eruption of the impacted tooth into its place in the dental arch. The extent of this time span is dependent on several factors, such as the initial distance between the tooth and the occlusal plane, the stage of the development of the particular tooth, the age of the patient, and the manner in which hard and soft tissue may be laid down in the healing wound. During this time period, therefore, local changes in the erupted dentition may occur as a result of the break in the integrity of the dental arch caused by the surgical procedure, such as space loss and tipping of the adjacent erupted teeth. This intervention is no less susceptible to the drifting of neighbouring teeth than is any other factor that may produce interproximal loss of dental tissue.

With an odontome or supernumerary tooth in the path of an unerupted permanent tooth, vertical (and sometimes mesial or distal or buccal or lingual) displacement of the permanent tooth is likely to be considerable. It would be convenient if the removal of the space-occupying body could be performed, leaving the decidious teeth intact, since the decidious tooth would maintain arch integrity during the extended period of time needed for the permanent tooth to erupt normally. Unfortunately, often, in order to gain access to perform the desired surgery, one or more decidious teeth need to be extracted. This being so, and having regard for the long distance that the displaced permanent tooth has to travel, space maintenance should be regarded as essential in most cases. It should be the first orthodontic procedure to be considered in these cases

and it should be retained until full eruption has occured.

Impacted teeth are often associated with a lack of space in the immediate area. This is frequently due to the drifting of adjacent teeth, although crowding of the dentition in general may be the prime cause. In such cases, the spontaneous eruption of an impacted tooth is unlikely to occur unless adequate or, preferably, excessive space is provided. It would be convenient if the excision of the associated pathologic entity could be comfortably delayed until this time, to bring about the desired eruption and to permit this corrective treatment to be attempted when the root development of the unerupted tooth is adequate. However, the surgeon will insist on removing most forms of pathology as soon as a tentative diagnosis is reached, in order to obtain examinable biopsy material for the establishment of a definitive diagnosis. Odontomes and supernumerary teeth are generally considered to be exceptions to this rule, and the timing of their removal may be more leisurely considered (21, 68, 75, 86).

4.2.3 Surgical Intervention

The timing and nature of the surgical procedure are determined by the degree of development of the teeth concerned at the time of initial diagnosis. At an early stage, a radiographic survey of a very young child may reveal pathology, such as a supernumerary tooth, an odontome, a cyst or benign tumor, that appears likely to prevent the normal and spontaneous eruption of a neighbouring tooth (60).

At this stage from every point of view, it would be inappropriate to expose the crown of an immature tooth. In the first place, one would not want to encourage the tooth to erupt before an adequate (half to two-thirds) root length had been produced. Secondly, at this early stage of its development, the tooth can not be considered as impacted, and, given time and freedom to manoeuvre, will probably erupt by itself. Early exposure risks the possibility of damage to the crown and to the subsequent root development of the tooth (60).

Nevertheless, with the discovery of the pathologic condition, the potential for impaction exists, and leaving the condition untreated will worsen the prognosis. Accordingly, removal of the pathological entity, without disturbing the adjacent permanent teeth or their follicular crypts, should be the aim of any treatment at that time. It may then reasonably be expected that normal development and eruption will

occur in the fullness of time. Whilst this is an obviously desirable course of action, access to the targeted area may be thwarted by the presence and closeness of adjacent developing structures, and delay may still be advised.

On the other hand, if this condition is only discovered much later, the permanent teeth may justifiably be defined as impacted, and the aims of surgical treatment become twofold: first, to eliminate the pathology, and then to create optimal conditions for the eruption of the permanent tooth, which is already late. This will usually involve exposure of the crown of the tooth. For many teeth, given adequate space in the dental arch and little or no displacement of the impacted tooth, spontaneous eruption may be expected (75). There are several situations and tooth types where this may not occur, or it may not occur in a reasonable time frame, often because of severe displacement of the affected tooth. For these cases, the natural eruptive potential of the tooth is supplemented and diverted mechanically, with the use of an orthodontic appliance (12, 68, 86).

4.2.4 Patient Motivation and Orthodontic Option

Impacted teeth are frequently encountered clinical problem among patients being treated in a typical orthodontic practice. Considerable interest is attached to the presence of impacted teeth in an orthodontic patient, not only on account of the pathologic conditions they may produce, but also because of their impact on the diagnosis and treatment planning process required for each individual patient.

The type of treatment prescribed for an impacted tooth depends on the particular tooth impacted; the field of specialty of the practitioner first involved, whether a general dentist, periodontist, orthodontist, or oral surgeon; and the level of that practitioners' experience with this problem. Such treatment may be as simple as observation and monitoring, or more complex, including surgical extraction, surgical exposure with or without orthodontic traction (via a variety of methods) or autotransplantation (3).

Patients rarely go to their dentist with a chief complaint of an impacted tooth and, since there is often no pain or swelling, they are commonly unaware that this abnormality is present. Generally, it is the family dentist who first observes the presence of a retained primary tooth and then radiographically discovers an impacted permanent tooth. Impacted permanent teeth are a relatively common anomaly among patients seen

in a typical orthodontic practice. Mead (72) reported on 1462 full mouth radiographs of 'white people' who were patients at his office, with no ages mentioned, and found an incidence of 18.9% having at least one impacted tooth, of which 1.6% were impacted maxillary canines.

Once an impacted maxillary canine has been diagnosed and localized, and any preventive/interceptive measures have failed in normalizing the position of the tooth, some type of active treatment is needed. There are many proposed treatment alternatives for the correction of the impacted canines in the literature. Consideration needs to be given to the attitude of the patient, the space present at the canine site and in the arches generally, the general state of the dentition, mobility and/or resorption of adjacent teeth, the position of the canine, the presence of a dilaceration of the root of the impacted canine, the age and health of the patient, and surgical difficulties and/or contraindications to surgery. Some of the more common methods of treating a patient with an impacted maxillary canine, as summarized by Bishara (16), include:

1) No treatment.

2) Extraction of the impacted canine and movement of the first premolar into its position.

3) Extraction of the impacted canine and prosthetic replacement of the canine.

4) Extraction of the canine and a segmental osteotomy to move the buccal segment mesially to close the space.

5) Surgical exposure, allowing natural eruption to occur.

6) Autotransplantation of the impacted canine.

7) Surgical exposure of the canine with orthodontic treatment to bring the canine into proper occlusion.

The patient may not wish to consider treatment of the impacted canine if they feel that their appearance is satisfactory with the deciduous canine in place. In these cases the patients need to be warned of the possible sequelae of leaving the impacted tooth in the alveolus, and of the need for periodic radiographic monitoring of the retained impacted permanent canine.

The patient may opt for the removal of the impacted canine, to prevent some of the possible problems from occuring, but leaving the deciduous canine in place. They must be advised that the prognosis for the deciduous canine lasting for their lifetime is

slim, and that some prosthetic dental treatment or orthodontic treatment will probably be needed in the future.

The most common method of bringing palatally impacted canine into occlusion is via surgical exposure, affixing some kind of attachment to the canine, and orthodontically pulling the tooth into the arch. There are many ways which have been used to place an attachment on the impacted canine to provide the force to bring it into the line of occlusion. These include cementing a pin into a hole drilled in the incisal of the canine (64, 94), fabricating a cast onlay or band with a loop to cement over the exposed canine (40, 53, 64), cementing a celluloid crown form with a piece of band metal inserted into a slot in the crown form to which traction can be exerted (91), tying a ligature wire around the canine crown (20, 111), cementing a preformed orthodontic band (104), embedding a wire loop into a prepared cavity in the crown of the impacted tooth and filling the cavity with restorative material (15), and cementing a buton on to the dry impacted canine with Durelon (92). Today, the most common method of fixing an attachment to an impacted canine is to etch the dry tooth with acid and bond a button, eyelet or orthodontic bracket directly to the tooth, either at the time of surgery or soon thereafter.

However the attachment is made to the tooth, a force must then be applied to bring the impacted canine into position. Some recommended the use of a removable appliance and elastics to apply the force, reasoning that it is more economic and provides better control of the force direction than full banding (8, 43, 69, 79).

Vardimon et al. (101) recommended the use of a magnet bonded to the canine and an attracting magnet in a removable acrylic appliance to erupt the impacted canine into occ1usion. These authors felt that this replicates normal eruption better than other methods, involves a less invasive surgical procedure, provides for well-controlled spatial guidance, and decreases the hazards of bone loss and root resorption. Sandler (83) also advocated the use of magnetic system as a modern alternative approach in the eruption of impacted teeth.

Bishara (16) summarized some of the methods of applying traction to an impacted tooth, which includes the use of light wire springs soldered to a heavy labial or palatal base wire, or directly to rnolar bands, mousetrap loops, or a 'balista spring'. Some of the newer orthodontic materials have expanded the repertoire of materials

which can be very effective in moving an impacted tooth, such as elastic threads, elastomeric chains, nickel titanium springs and nickel titanium wires. The methods of applying a traction force to a palatally displaced canine are now limited only by the imagination of the orthodontist (9, 15, 27, 40, 67, 74, 92, 98, 111).

Early methods of surgical exposure of impacted canines endorsed extensive bone removal to expose the crown of the impacted tooth, mainly for access to place a cast crown or steel ligature on the crown, but also to provide an easier path for tooth movement. The exposure was left open and packed with surgical paste, or a crown form was cemented over the crown of the impacted canine until the soft tissue healed, some natural eruption occured, and the tooth was then orthodontically brought into occlusion (40, 94).

Kohavi, Becker and Zilberman (55) compared the health of the supporting tissues of impacted canines exposed with a 'heavy' exposure or a 'light' exposure. They summarized their findings by stating that the most serious damage that occurs in the treatment of palatally impacted canines is the result of surgical intervention which exposes the cementoenamel junction of the impacted tooth. This damage is in the form of loss of supporting tissues, including bone support, of the previously impacted canine.

Today, the two techniques of surgically exposing and bringing the palatally impacted canine into occlusion are the 'open eruption' and the 'closed eruption' techniques. Both techniques require the least amount of bone removal that is necessary to bond an attachment to the crown of the impacted canine**.**

4.3 BUCCALY ECTOPIC CANINES

4.3.1 Aetiology

Labial impaction of the maxillary canine is less frequent than palatal impaction and is often caused by insufficient arch length. The canine is often positioned high in the alveolar bone and erupts through the alveolar mucosa.

Crowding is the principle cause of buccaly displaced canines. In general, crowding of the dentition results in the exaggerated displacement of a tooth from its developmental position in the arch. The developmental position of the maxillary lateral incisor is lingual to the line of the arch. Thus when crowding affects the early mixed

dentition, there will be insufficient space for the lateral incisor to migrate labially between the root of the central incisor and the deciduous canine teeth, which is the manner in which it normally comes into the dental arch. It therefore continues to develop downwards, but in a lingual position, and erupts lingual to the adjacent teeth.

The normal eruption path of the permanent canine is buccal to the line of the arch, and the lateral incisor and first premolar, the teeth immediately adjacent to the canine, erupt before the canine. Thus, in the presence of crowding, there will be reduced space in the arch in the canine area, and the close proximity of these adjacent teeth will prevent the canine from moving into the arch. The vertical development of the maxillary permanent canine will therefore be accompanied by its buccal displacement. Whether the tooth eventually erupts or remains impacted is irrelevant, although buccal impaction is most unusual.

4.3.2 Diagnosis

Unerupted permanent maxillary canines cause the patient relatively few problems. A retained deciduous canine may have a relatively poor appearance compared with a properly aligned permanent canine, but most patients do not seek treatment for the retained deciduous canine.

The diagnosis of buccaly ectopic canines is based on clinical and radiographic examination, radiographs allowing the accurate location of the impacted tooth (36). When detected early, prevention of impaction may be achieved by the extraction of the deciduous canine, which may allow spontaneous correction of the malposition (81).

4.3.3 Treatment Timing

As stated earlier, buccal impaction of the maxillary canine is less frequent than palatal impaction and is often caused by insufficient arch length. As a result, the canine is often positioned high in the alveolar bone and erupts through the alveolar mucosa. Fournier et al. (43) suggest that labially impacted teeth with a favorable vertical position may be treated initially by surgical exposure but without the application of a traction force. He believes that in younger patients the tooth will erupt on its own after surgical exposure, whereas in older patients traction is almost always indicated.

The absence of an adequate band of attached gingiva around the erupting canine may cause inflammation of the periodontium. Vanarsdall and Corn (100) emphasized that it is hazardous to move teeth in the presence of inflammation. Tissue resistance to the stresses of mastication and function is less than optimal, and loss of periodontal support is possible if precautions are not taken to alleviate such potential problems.

Therefore it is recommended that surgical procedures designed to expose impacted canines erupting through alveolar mucosa should simultaneously provide a band of attached gingiva to the exposed tooth. Otherwise, improper soft-tissue management may lead to mucogingival recession and loss of alveolar bone.

Before a labially impacted canine is exposed, careful consideration should be given to creation of sufficient space to allow for the canine to be positioned in the arch. The created space will also provide an adequate zone of attached gingiva that can act as a donor site for a partial-thickness apically or laterally repositioned flap.

Vanarsdall and Corn (100) suggested that the flap containing the keratinized tissue should be placed to cover the CEJ and 2 to 3 mm of the crown. They explained that the advantages of such an approach are that (a) the new gingival attachment prevents the marginal bone loss and gingival recession that is frequently encountered with surgical exposure of impacted teeth; (b) the need for a series of dressings or the placement of a polycarbonate crown to prevent the tooth from being covered by granulation tissue is avoided; (c) the procedure is indicated even in teeth located beyond the vestibular depth or mucobuccal fold; and (d) the apical repositioning of the flap allows for greater movement of the marginal tissue. This will minimize tension on the gingival tissues, particularly in those cases in which the canine, with its newly attached gingival tissue, needs to be moved occlusally a long distance to reach its proper position.

During the surgical procedure if bleeding makes bonding of an attachment difficult, Vanarsdall and Corn recommended placement of a surgical dressing to protect the tissues for 7 to 10 days. After removal of the dressing, a direct bonded attachment can be placed in a dry field and tooth movement can then be initiated (100).

Kohavi et al. (57) studied the periodontal health of labially impacted maxillary canines after their orthodontic alignment. They observed significant differences in the amount of the attached gingiva available on the labial aspect of the previously impacted

canines as compared with the contralateral teeth. On the average, the contralateral teeth had approximately 1 mm more attached gingiva than the treated teeth. The treated teeth still had more than 3 mm of attached gingiva, which is considered physiologically adequate.

Therefore the creation and preservation of a functional band of attached gingiva should be an important objective in the management of labially impacted teeth. The attached gingiva could be made available through an apically repositioned flap, a laterally repositioned pedicle graft, or, when necessary, a free gingival graft.

4.4. PALATALLY IMPACTED CANINES

4.4.1 Aetiology

Throughout the period of its downward progress, the permanent canine is conspicuously palpable on the buccal side of the alveolar ridge, from as early as 2 or 3 years prior to its normal eruption, which normally occurs at the age of 11-13 years.

Usually, there is no single cause of the palatal displacement of the maxillary canine tooth. Theories regarding to the causes of palatal displacement are:

1. Long path of eruption: From the early days of Broadbent, in the 1940s, the most common reason given for palatal displacement of the permanent maxillary canine was the fact that it had a long and tortuous eruption path, beginning close to the floor of the orbit. It was considered that this tooth had much further to travel before it erupted into the mouth and that it therefore had a greater chance of 'loosing its way'. This has been standard teaching for many years.

2. Crowding: The normal eruption path of the permanent canine is buccal to the line of the arch, and the lateral incisor and first premolar, the teeth immediately adjacent to the canine, erupt before the canine. Thus, in the presence of crowding, there will be reduced space in the arch in the canine area, and the close proximity of these adjacent teeth will prevent the canine from moving into the arch.

In a series of more recent clinical research studies, Jacoby (52), Becker (11) and Brin et al. (21) have pointed out that the likelihood of palatal displacement is much reduced where crowding is present. On the contrary, they have shown it to be a far more prevalent occurance when there is excessive space in the dental arch.

The purpose of Jacoby's (52) work was to establish the relationship between arch length and canine impaction by separating the labial impactions from the palatal impactions. In this study, 85% of the 40 palatally displaced canines had sufficient or excess space in the arch to erupt. Two of the palatal canines (5%) were thought to be related to agenesis of the ipsilateral lateral incisor, while four (10%) were thought to be related to peg-shaped lateral incisors. Two of the palatal canines in which there was not sufficient space in the arch occured in the same patient who the author felt had a general hypodevelopment of the skeletal tissues and had some hidden symptoms of cleft palate. Of the remaining four palatally impacted canines without sufficient space in the arch, two of the patients had the opposite maxillary canine labially displaced, while one other had a crossbite on the side with the palatally impacted canine. In contrast, only one of the labially displaced canines showed sufficient space in the arch for the canines. Jacoby felt that it is evident that arch-length deficiency is the major etiologic factor in labially displaced canines. In contrast, he stated that excessive space in the maxillary canine area could allow the canine to move palatally in the bone and find a place behind the buds of the other teeth and eventually become palatally impacted. Jacoby suggested that labially displaced canines be referred to as *unerupted* while the term *impacted* be used only for palatally displaced canines.

3. Non-resorption of the root of the deciduous canine: Lappin (62) considered that it was the failure of the root of the deciduous canine to resorb that caused a palatal deflection of the eruption path of the permanent canine, leading to its impaction.

4. Trauma: Brin et al. (22) have illustrated how trauma, which leads to a cessation in the development of a lateral incisor root, may be associated with palatal canine impaction. They explain this by assuming that, **a)** the traumatic episode may have caused movement of the lateral incisor, or **b)** by conduction, movement of the unerupted canine itself, or **c)** in terms of the guidance theory, this is due to the shortness of the lateral incisor root, whose development ceased as the result of the trauma.

Brin, Solomon and Zilberman (22) presented two cases of trauma to the anterior area of the mouth that eventually resulted in an impacted canine on the affected side. In one case the trauma resulted in shortening of the root of the lateral incisor which these authors felt affected the path of eruption of the adjacent canine tooth. In the other case presented, the trauma produced a misalignment of the anterior segment which caused

the lateral incisor to lose 'the desirable relationship with the adjacent canine bud at a critical stage of dental development'. They recommended that special attention should be paid not only to the teeth directly injured by the trauma, but also to the development of apparently unharmed neighbouring teeth.

5. The guidance theory: The guidance theory suggests that a proper size and timely formation of the adjacent lateral incisor root is required to guide the erupting canine to its proper location in the arch. Should this root be smaller than average or late in formation then the canine has a greater chance of becoming displaced palatally.

Becker (12) noted that the congenital absence of the adjacent permanent lateral incisor has an influence on the eruption of the canine. He felt that the smaller root of the retained deciduous lateral incisor allows the canine to pass medially over its apex and then become palatally impacted.

Becker, along with various colleagues, has done much research on the incidence of anomalous maxillary lateral incisors in relation to palatally displaced canines. In an early publication, Becker et al. (6) obtained 55 cases of palatally displaced canines from 633 consecutive patients from an orthodontic practice and an additional 33 cases fulfilling the same criteria from the orthodontic department of a dental school and another private practice. They classified the lateral incisors adjacent to the palatally impacted canine as absent, peg-shaped, small (mesio-distal width equal to or smaller than its mandibular counterpart), or normal. Their results showed that females were affected with a palatally displaced canine 2.5 times more than males, and in 45% of all cases the impaction was bilateral. These researchers found that in almost half the cases (48%) the adjacent lateral incisor was either absent or of an anomalous size. They believed that small or peg-shaped lateral incisors tend to develop later than normal and are insufficiently developed to provide critical guidance in the very early stages of development and migration of the canine. Absent lateral incisors are obviously also unable to provide this needed guidance. They found that their 5.5% rate of congenitally absent lateral incisor in their palatal canine population was much higher than that seen in the general population (2.1% in a Jewish population that they quoted, 0.5% in a Canadian population (87)). Becker et al. (6) suggested that there appear to be two processes in the palatal displacement of the maxillary canine. The first is a developmental one where the absence of guidance by the congenitally missing, late-

developing, or small-rooted adjacent lateral incisor allows the erupting canine to move towards the palatal side. The second one related to a later period, when the canine is moving down into the narrower part of the alveolus and then is prevented from its normal labial movement by the roots of the permanent lateral incisor.

An evaluation of 70 palatally displaced canines and 106 controls done by Becker and others (7) found the average length of lateral incisors adjacent to a palatally displaced canine to be 2.12 mm shorter than those adjacent to normally erupted canines, with 1.4 mm of this discrepancy attributable to a shorter root. The length of the central incisors was not found to be significantly different in the two groups. They concluded that there is a definite link between small lateral incisor crown size and the incidence of palatal displacement of the adjacent canine; there is a link between a short lateral incisor root and the incidence of palatal displacement of the adjacent canine; and there is a definite link between lateral incisor crown size and root size. They thought that the shorter root, together with the lateness of development anomalous teeth, deprive the canine of needed guidance in the early stages of development.

6. Heredity: Genetics is involved, either involving only the lateral incisors and subsequent lack of mechanical guidance for the canine, or having a larger role and being responsible for the abnormal position of the canine, the anomalous size or absence of the lateral incisors, and other anomalies which may occur with a palatally impacted canine.

4.4.2 Diagnosis

The discovery of palatal impaction is usually made by the general dentist, at the time of routine dental examination.

Most authors agreed that maxillary canines have usually erupted into full occlusion by approximately 12 years of age (23, 31, 40). After this age the absence of a canine in the arch, without a history of extraction, usually suggests that it is impacted. Very rarely is a maxillary canine congenitally absent.

Ericson and Kurol (34) recommended the following indications for radiographs: 1) asymmetry on palpation or a pronounced difference in eruption of canines on the left and right sides; 2) the canines cannot be palpated in the normal positions and the occlusal development is advanced; 3) the lateral incisor is late in eruption or shows a

pronounced buccal displacement or proclination.

Others (41, 61, 98) suggested that the inclination of the lateral incisor may give a clue to the position of the unerupted canine. A distal inclination of the lateral incisor (ugly duckling stage) indicated a close relationship of the canine crown to the incisor apex. If the lateral incisor crown has a labial tilt then the crown of the canine will often be found on the labial aspect of its root. Palatal displacement of the canine usually does not affect the position of the lateral incisor but in some cases the latter tooth will be retroclined, possibly in crossbite. Mobility of the lateral incisor suggests resorption of its root, often due to malposition of the canine.

So, where it is not possible to palpate the canine by about ten years of age, and an ectopic path of eruption is suspected, then radiographic assessment is necessary to localize the canine.

4.4.3 Treatment Timing

From the age of about 9 or 10 years, it is usually possible to palpate a normally developing maxillary permanent canine tooth on the buccal side of the alveolus, high above its deciduous predecessor. The greater the degree of crowding, particularly after the eruption of the first premolar, the more buccal is the displacement and the more palpable will the canine become, as its eruptive process brings it further and further down on that side of the arch.

In the event that the tooth is not palpable at this age, radiographs should be taken to assist in locating the tooth accurately and to secure other information regarding the presence, size, shape, position and state of development of individual unerupted teeth and any pathology. In a patient younger than 9 years, the radiographs will not usually show abnormality in the position of the unerupted canine teeth, even if the canines are not palpable and even if they are destined subsequently to become palatally displaced.

Many of these non-palpable canines will finally erupt into good positions in the dental arch, in their due time, provided that there is little or no mesial and palatal displacement of the crown of the unerupted tooth. It may be argued that even canines with an initial mild palatal displacement will achieve spontaneous eruption and alignment despite a first stage displacement, if they undergo secondary correction. Other canines, however, will not erupt, and their positions may worsen in time, as may

be seen in follow-up radiographs (12).

4.5 PREVENTION/INTERCEPTION OF MAXILLARY CANINE IMPACTION

It would seem to be a wise course of action to prevent or intercept the impaction of the maxillary canine and prevent the detrimental sequelae which can occur due to this anomaly. Broadbent, in a communication to Lappin (62), demonstrated by taking a series of anteroposterior and lateral headfilms of children, starting at the age of 6 years, and at intervals of 3-6 months, that it is possible to observe with great accuracy the path of eruption of the permanent canine. By noting deviations from normal, Broadbent could predict an abnormal eruption path of the permanent canine and would then remove the deciduous canine so that the permanent canine could then assume its normal position and not become palatally impacted. This would be an effective solution to prevent canine impaction but it is no longer ethical to take radiographs every 3-6 months on children to monitor the remote possibility of an impaction occurring.

Williams (106) recommended the dental age of 8 years to be the best time to begin observation of the intra-bony eruption of the canine for detection of possible complications. In Class I uncrowded malocclusions where maxillary canine bulges are absent, he recommended radiographs to ascertain the position of the permanent canine. If the canine appeared to have a mesial tilt and a position lingual to the incisor teeth, Williams suggested the removal of the deciduous canine. The extraction of the deciduous canine can also be helpful at later ages, but he said that the final improvement in the permanent canine position may not be as successful as that seen at the earlier age.

Recommendations by Ngan et al. (77) included observation of the intrabony movement of the m axillary canine between the ages of 8 and 10 years, and early extraction of the primary canines to help redirect the path of eruption of the permanent canines if a problem is suspected.

In a frequently cited paper on the prevention and interception of maxillary canine impaction, Ericson and Kurol (32) followed 46 ectopic maxillary canines in 35 individuals, ages 10 - 13 years, in the first prospective longitudinal study on the prevention of palatal impaction. All cases showed no or minimal space problems. In all

of the cases the primary canine was extracted, with the result that 78% of the permanent canines showed a change to a normal eruption from the previously palatal position, most within 6 months and all within 12 months. None of the other cases normalized after 12 months. Their results showed that, in this age group, 91% of the canines normalized when the permanent canine crown was distal to the midline of the lateral incisor. Conversely, the success rate fell to 64% when the permanent canine crown was mesial to the midline of the lateral incisor. In contrast to earlier publications, Ericson and Kurol (32) recommended that before the age of 10 years, spontaneous correction of potentially displaced maxillary canines may occur and extraction of the deciduous canine is normally not indicated, unless the patient shows very early dental maturity. Extraction of the deciduous canine is the treatment of choice in the age group 10-13 years when the permanent canine has a palatal ectopic eruption path.

Jacobs (50) published two case reports which followed the guidelines of Ericson and Kurol (32) which were both successful in intercepting a potential palatal impaction of maxillary canines. Jacobs (49) also published two case reports which were outside the guidelines of Ericson and Kurol (32) but which were also successful in correcting the path of eruption of palatally displaced canines. This latter study suggested that extracting the primary canine and allowing 12 months of observation to see if the permanent canine does correct its path of eruption may be worth trying in most palatally impacted canine cases.

In a more recent prospective study (81), 39 consecutive patients with 47 palatally displaced canines, age range 9.3 - 14.5 years, were followed for two years after the extraction of the deciduous canine. Two patients aged 9.3 years showed early dental development and the 14.5 year old showed late dental development. Overall 62% of the canines achieved a normal eruptive position, 19% showed some improvement and a further 19% failed to improve or their position deteriorated. Of the 17 permanent canines which were mesial to the midpoint of the adjacent lateral incisor, only 5 successfully erupted into position (29% success compared to Ericson and Kurol's (32) 64% success). Of the 22 canines that overlapped the adjacent lateral incisor root by half or less, 16 (73%) were successfully normalized. When no overlap was present there was a 100% success rate. A reported trend was that the chance of a successful return of the canine to a normal eruptive pathway decreased if the original canine angulation

exceeded 31 degrees. However, the angulation effect exerted less influence on the chance of success than the degree of overlap of the adjacent incisor root. Vertical height and eruptive distance were not found to be significant factors.

4.6 SURGICAL EXPOSURE OF IMPACTED CANINES

4.6.1 Management of Buccaly Ectopic Canines

Buccally ectopic maxillary canine is less frequent than palatal impaction and is often caused by insufficient arch length. As a result, the canine is often positioned high in the alveolar bone and erupts through the alveolar mucosa.

The absence of an adequate band of attached gingiva around the erupting canine may cause inflammation of the periodontium. Therefore it is recommended that surgical procedures designed to expose ectopic canines erupting through alveolar mucosa should simultaneously provide a band of attached gingiva to the exposed tooth. Otherwise, improper soft-tissue management may lead to mucogingival recession and loss of alveolar bone.

Before a buccaly ectopic canine is exposed, careful consideration should be given to creation of sufficient space to allow for the canine to be positioned in the arch. The created space will also provide an adequate zone of attached gingiva that can act as a donor site for the surgery.

The most common methods of uncovering labial impacted canines are: **a)** the simple surgical exposure, **b)** the closed-flap eruption technique, and **c)** the apically positioned flap technique (19, 26, 47, 71, 89, 100).

Simple surgical exposure: The simple surgical exposure includes the excision of the covering tissues of the crown of the impacted tooth. Tegsjö et al. (95) observed that the width of keratinized gingiva of the treated canines with a simple but "radical" surgical exposure alone was significantly reduced compared to the contralateral normally erupted canines. In addition, the sulcus depth of the treated canines was significantly lower and the gingival recession was significantly increased in comparison to the contralateral control ones. Boyd (19) compared the "window approach" (exposure of the entire labial aspect of the anatomic crown with total excision of the keratinized tissue), with a more conservative surgical approach which exposed only 4-5 mm of the

most superficial portion of the labial aspect of the cusp, maintaining 2-3 mm of keratinized tissue. Evaluation of twelve patients in each category six months to two years after orthodontic alignment revealed that those treated by the window approach presented statistically more gingival recession, gingival inflammation and loss of attachment on the labial and labio-proximal surfaces of the impacted teeth when compared to controls. These findings were confirmed also by Kohavi et al. (57) and by Artun et al. (2), who found significantly less attached gingiva and loss of attachment on labially erupting maxillary canines after their orthodontic alignment.

The closed-flap eruption technique: In the closed-eruption technique a flap is elevated, an attachment is placed on the impacted tooth, and then the flap is returned to its original location (73). Vermette et al. (103) observed that the width of the attached gingiva of the labially impacted canines treated with the closed-eruption technique, was reduced on the distal surface and the crestal bone was located more apically on their facial surface of them than of the untreated control canines. Crescini et al. (27) reported on the periodontal effects of the closed surgical technique with tunnel traction for deep infra-osseous labially impacted canines. They found no attachment loss and no recession at the end of active treatment and after three years follow-up. In addition, no significant differences were observed in the width of keratinized tissue between the surgically uncovered and the contralateral spontaneous erupted canines.

The apically positioned flap technique: In the apically repositioned flap technique, a partial thickness flap is raised and the wound is carefully curetted to remove the dental sac and to expose the tooth. There is no need for bone removal unless it is necessary to reach the canine crown. The latter must be executed as conservatively as possible and not beyond the cemento-enamel-junction. Interrupted periosteal sutures are placed to position the flap apically and the surgical area is packed for 7-10 days (73). According to Becker (12), when an apically repositioned flap is performed, tooth eruption is speeded up. This method is not recommended if the impacted tooth is very high positioned, since the apically repositioned flap would then leave a wide area of the labial bony plate unnecessarily exposed to the oral environment. Nevertheless, an important advantage of this method is that the buccally impacted canine remains accessible for attachment bonding at any appropriate later date, if the orthodontist decides for an active extrusion. Regarding the periodontal conditions following use of

this technique, Vermette et al. (103) found that the gingival margin of labially impacted canines uncovered with the apically positioned flap technique was located more apically on the mesial and facial surfaces, and more bone was lost on the mesial, facial and distal surfaces than in the control canines. On the contrary, Tegsjö et al. (95) observed no significant differences in the periodontal status between treated canines and the non-treated contralaterals.

4.6.2 Management of Palatally Impacted Canines

There are numerous surgical methods for exposing the impacted canine and bringing it to the line of occlusion. Two of the most commonly used methods are **1)** surgical exposure, allowing natural eruption, and **2)** surgical exposure with placement of an auxiliary attachment. Orthodontic forces are subsequently applied to the attachment to move the impacted tooth.

Surgical exposure to allow natural eruption to occur; This method is most useful when the canine has a correct axial inclination and does not need to be uprighted during its eruption. The progress of canine eruption should be monitored with roentgenograms with the use of reference points such as an adjacent tooth or the arch wire.

The main disadvantages of this approach are the spontaneous but slow canine eruption, the increased treatment time, and the inability to influence the path of eruption of the impacted canine.

Surgical exposure with the placement of an auxiliary; After the surgical exposure of the impacted tooth, an auxiliary is attached to the crown. Such an auxiliary can be either directly bonded to enamel or indirectly attached to a cemented band or crown.

Two approaches are generally recommended in regard to the timing of placing the attachment:

1. The first method is a **one-step approach**; The attachment is placed on the tooth at the time of surgical exposure using either an open- or a closed-surgical exposure (70). The tissues over the attachment should be excised, and a periodontal pack should be placed. The pack will minimize patient discomfort and prevent the granulation tissues from covering the attachment before the clinician is ready to apply

traction forces on the impacted tooth. This approach is particularly recommended for palatally impacted teeth. One of the important advantages of such an approach is that when the force is applied to the impacted tooth, the clinician is able to visualize the crown of the tooth and to have better control over the direction of tooth movement. This will avoid moving the impacted tooth into the roots of the neighboring teeth (17).

Regarding the **open surgical exposure**, a gingival flap is reflected and the bone over the crown is removed. The soft tissue in the flap is excised and a window to expose the crown of the impacted tooth is created. Then the flap is re-approximated and after bonding of an orthodontic attachment a periodontal dressing is placed in order to prevent the window from closing. According to Becker et al. (5), the one step approach is superior to the two-step-approach; the ability to gain attachment permits a more conservative approach to the exposure. However, the palatal mucosa is very thick and will leave a broad cut surface, which will tend to close over unless its edges are more radically trimmed back and the dental follicle is removed. Thus, when the tooth is placed deeply, the exposure will additionally need to be maintained using a surgical pack. This type of approach will therefore leave the tooth with a soft tissue deficiency and a long clinical crown at the completion of the orthodontic alignment (12).

The open surgical exposure presents some advantages such as ability of the orthodontist to observe and have a continuing access to the impacted tooth as it is moved to its normal position in the dental arch (100, 107), as well as faster eruption (100). However, this method is often associated with multiple periodontal problems, such as gingival recession (19, 73, 95, 100), bone loss (100), decreased width of keratinized gingiva (57, 95), delayed periodontal healing (5), and gingival inflammation (95).

Regarding the **closed-surgical exposure,** a mucoperiosteal flap is raised exposing the crown of the impacted tooth, the bone covering the crown is removed, an attachment is bonded and the flap is repositioned. An eyelet wire or (gold) chain connected to the attachment exits through the flap into the oral cavity to gain attachment to the fixed appliance for immediate traction (71).

In addition to eyelet wires or chains, several other kinds of orthodontic attachments have been used in order to erupt impacted teeth, such as threaded pins, cast gold inlays, gold cups with cleats, ligature wires, bonded attachments, bands, and

extracoronal caps. Some of them can produce more damaging effects than others to the periodontium, the impacted tooth, or the adjacent teeth. For example, a threaded pin can damage the pulp of an impacted tooth (97), a circumferential ligature wire can cause ankylosis, external resorption, and alveolar bone loss (20, 88), while gold cups, inlays, bands, and extracoronal caps require significant bone removal.

Wisth et al. (108) compared the periodontal status between treated impacted canines which had been moved by means of orthodontic forces and the contralateral control ones, which had erupted unaided, and found that the pocket on the distal surface was significantly deeper in the treated impacted canines. Both the buccal and the palatal surfaces of the previously impacted canines displayed significantly greater loss of attachment than the control teeth did. The significant difference between the loss of attachment on the buccal surface of both the previously impacted canines and the control teeth, confirms the findings of Zachrisson and Alnaes (110), according to which the pressure side is particularly prone to exhibit periodontal destruction, even when it is not related to an extraction site.

Hansson and Rindler (45) observed an increased depth of the mesio-lingual and mesio-labial pockets of the previously impacted canines which were orthodontically moved after surgical exposure (a flap had been raised and resutured after bone removal in 11 of the 42 cases examined), compared to the canines of the untreated contralateral control site. They also noticed that the marginal bone level was significantly lower on the distal surface of the treated canines, but they concluded that in general their results showed a good gingival and periodontal status with slight differences between treated and untreated sides. In a comparison of the probing attachment level between the treated impacted canines and the untreated contralateral ones, Woloshyn et al. (109) observed an increased probing attachment level at the mesial and distal aspects of the treated canines, while the crestal bone height was significantly lower at the mesial aspect of the previously impacted canines than at the control ones. These results agree with the findings of Becker et al. (4), who also observed that the mean pocket depth was significantly greater in the previously impacted teeth and the bone support was also significantly lower on the distal and on the mesial side of these teeth as well.

2. The second method is a **two-step approach**; First, the canine is surgically uncovered and the area is packed with a surgical dressing to avoid the filling in of

tissues around the tooth. After wound healing, within 3 to 8 weeks, the pack is removed, and an attachment is placed on the impacted tooth (64).

Earlier methods of uncovering impacted canines advocated radical bone removal to expose the crown of the impacted tooth so as to remove all bony obstacles and to provide an easier path for tooth movement. McDonald and Yap (69) evaluated the relationship between the amount of bone removed during surgical exposure and the subsequent bone loss around the impacted tooth. They found that the more bone removed initially, the greater the bone loss after orthodontic treatment. Kohavi et al. (56) compared the periodontal health of canines exposed by such a "radical" exposure with those exposed by a more conservative "light" exposure. In the latter group, sufficient soft and hard tissues were removed mainly to allow for the placement of a bond, but the exposed area was kept coronal to the cementoenamel junction (CEJ). Comparisons between the two groups indicated the absence of significant differences in the plaque index, the gingival index, pocket depth, or attached gingiva after treatment. However, there were significant differences in bone support, i.e., alveolar bone support in the "heavy exposure" group was reduced. It was concluded that exposure of the CEJ was a critical variable and should be avoided as an objective during surgery or during the placement of a wire lasso with or without a gold chain. Kohavi et al. (56) further suggested that light movements (e.g., tipping) cause significantly less bone loss than heavy movement (e.g., torque) during the traction of the impacted tooth.

It can therefore be concluded that the combined effects of light surgical exposure and light orthodontic movements and forces are beneficial to the future periodontal health of the tooth since they minimize the loss of alveolar bone support and potential injury to the tooth during traction.

It should be reemphasized that in the surgical exposure of an impacted tooth, only enough bone should be removed to allow for the placement of a bracket and that during the procedure the CEJ should not be intentionally exposed.

4.7 TREATMENT STRATEGY OF IMPACTED CANINES

4.7.1 Orthodontic Treatment Duration

Studies on the evaluation of factors which affect the duration of orthodontic

treatment suggest that treatment time can vary widely between offices and in the same office, dependig on the particulars of the individual case (13, 42). Some of the most important factors which explained the variability in treatment duration include: the number of missed appointments, number of extracted premolars, number of brackets and bands replaced or recemented, the necessity of wearing headgear, and the severity of the malocclusion at the start of treatment. The one study which included impacted canines as a variable had nothing to report on its effect on treatment duration (42).

Published literature (4, 24, 80, 107, 109) suggested that the duration of treatment for orthodontic cases involving palatally impacted canines took an average of 18 months to 30 months, with a wide range for individual cases. None of the above studies used a control group to compare treatment duration of non-impacted canine cases from the various offices used. No literature was found which examined whether the initial position of the canine, or whether unilateral or bilateral, had an effect on the treatment duration.

4.7.2 The Anchor Unit

For most malocclusions, quality treatment is best provided by the use of one or other of the recognized fixed appliance treatment techniques. If the dental arches are correctly related and adequate space is present then the teeth are initially 'levelled' to a labial archwire of standardized archform and a given coefficient of elasticity. Later, heavier round or rectangular archwires are substituted to perform root movements that will pave the way to achieving an optimal result. Incorrectly related dental arches will benefit from the use of other appliances, such as headgears, functional appliances and intermaxillary elastics, prior to or in addition to the fixed appliances, while space may be provided by the extraction of teeth or by expanding the arches mesio-distally or laterally.

When dealing with a malocclusion that incorporates an impacted tooh, modifications must be made to this procedure. Unlike other teeth in the mouth, the impacted tooth may be severely displaced from its normal position in all three planes of space, and much anchorage will be expended in bringing it into alignment. Accordingly, it is necessary to develop a rigid anchor base against which to pit the forces required to reduce the impaction.

At the age at which an impacted maxillary canine is treated, the full permanent dentition (with the exception of third molars) is almost invariably present. Accordingly, a fully multibracketed appliance should normally be placed and the entire dentition treated, through the stages of leveling and the opening of adequate space in the arch for the impacted tooth. A heavy and more rigid archwire is then placed into the brackets on all the teeth of the fully aligned and complete dental arch. The aim of this is to provide a solid anchorage base that will not allow distortion of the archwire to occur as a result of the forces that will eventually be applied to the impacted tooth after its exposure. The effect on the anchor unit of forces designed to resolve a grossly displaced canine should not be underestimated, particularly if they are applied for an extended period.

4.7.3 Attachments

To be in the position of being able to influence the future development of an impacted tooth, it is necessary to place some form of attachment on the tooth. These attachments have changed over the years, reflecting the advances made in the field of dental materials.

Lasso wires : In the years prior to mid-1960s, a lasso wire twisted lightly around the neck of the canine had been employed widely, and was used in the initial stages. It will be readily appreciated that the shape of the crown of a tooth is such that its narrowest diameter is at the CEJ, which is where the lasso wire will inevitably settle. This will result in irritation of the gingiva and prevent reattachment of the healing tissues in this vital area. It has also been reported that external resorption and ankylosis have been produced in the area of the CEJ following employement of this method (88). Given the excellent alternatives that are available today, the lasso wire is obsolete.

Threaded pins : Several systems of threaded pins have been available for many years. Their specific purpose is to provide retention for an amalgam or composite core, to allow the provision of a cast crown in a severely broken down tooth. These threaded pins may also be used to provide the attachment for an impacted tooth. This is a method that was used in the past (9, 54), but has been totally finished. Its disadvantages include the fact that it is dentally invasive, necessitating a subsequent restoration. Given the

difficulties of access to many impacted teeth and the desirability of limiting surgical exposure as much as possible, the orientation of the long axis of the tooth may be difficult to determine, and the drilled hole may inadvertently enter the pulp – unerupted teeth often have large pulp chambers. Nevertheless, the method is still in use in some quarters (58).

Orthodontic bands : Preformed orthodontic bands largely replaced the lasso wire, and clinical experience with them showed them to be considerably more compatible with ensuring the health of the periodontal tissues. As with the lasso wire, however, the use of a band dictated the very wide surgical clearance of tissue on all sides of the tooth, in order to adequately control haemorrhage around the crown and to avoid contamination from oozing blood inside the cement-filled band at the time of placement.

Since the introduction of enamel bonding, all of the above-mentioned earlier methods have become obsolete. The employment of the acid-etch composite bonding technique to the crown of a tooth has much merit (78), notably in terms of the simplicity and reliability of the bond. Its most important advantage is that it requires relatively little exposed surface of enamel for it to be successful – a fact that may contribute greatly to the subsequent periodontal health of the treated result. It is presently without doubt the method of choice from almost every point of view, and it should replace other methods in virtually all circumstances.

Standard orthodontic brackets : As far as the actual choice of type of attachment to be placed on impacted teeth is concerned, there are several salient points to consider regarding the impacted tooth when compared with an erupted tooth that requires to be brought into its position in the dental arch. Edgewise, Begg and other orthodontic brackets represent sophisticated designs of attachment that enable the orthodontist to perform any type of movement on a tooth in the three planes of space. It is not possible, however, to achieve more than tipping, extrusion and some rotation until the bracket reaches and fully engages the main archwire. In other words, its efficacy up to that point is no greater than that of a simple eyelet (5).

The base of a conventional bracket is wide, rigid and difficult to convert to the

shape of another part of the tooth's surface other than the mid-buccal, for which it has been designed. Thus composite bonding elsewhere on a tooth is very likely to lead to failure (5).

The standard orthodontic bracket in any technique is relatively large, possesses a wide, high and sharp profile, and, even when placed in alternative positions on the tooth, by force of circumstance at the time of surgery, it is inevitably deeply sited in the surgical wound. The bracket's shear bulk creates irritation as the tooth is later drawn through the soft tissues, particularly the mucosa. A ligature wire or elastic thread tied to it must also originate deep in the wound, and will be stretched across the replaced flap tissue towards the labial archwire. This increases the possibility of interference with the investing tissues, and leads to inflammation and to probable permanent periodontal damage.

As the displaced tooth moves towards its place in the arch, exuberant gingival tissue bunches up in front of it, which will also lead to impingement by a conventional orthodontic bracket. The existence of the exuberant gingival tissue in advance of the tooth can often cause 'pinching' between it and the teeth in the arch immediately adjacent to it. This is less likely to occur if a deliberately generous space is provided in the arch for the tooth, and this precaution may avoid unnecessary periodontal damage. Because of the close proximity of an impacted tooth to the roots of adjacent teeth, it is often impossible to bond a conventional bracket in its proper place on the tooth. Accordingly, the bracket may have to be sited on the palatal surface of the tooth, where it is preformed base is contoured very differently from the shape of the recipient (palatal) area of the tooth, compromising its retentive properties.

A simple eyelet : An eyelet, welded to band material with a mesh backing, is soft and easy to contour, making its adaptation to the bonding surface more accurate, which makes for superior retentive properties. Its relatively small size and low profile makes the midbuccal position of several of the more awkwardly placed teeth considerably more accessible when compared with the placing of a conventional bracket. Its modest, low-profile, dimensions are also less irritating to the surrounding tissues.

For these reasons, a small eyelet is recommended as the initial attachment,

placed at the time of surgery and removed only when the tooth has progressed to the point where it is in close proximity to the archwire. At that time, it should be substituted by the same type of sophisticated bracket that is being used on the other teeth, thereby permitting the initation of the more intricate root manipulations of the tooth (rotating, uprighting and torqueing).

There are important periodontal advantages to be gained by full closure of the surgical flap at the end of the visit during which the surgical exposure is performed. Thus the impacted tooth is re-covered by the surgical flap, and is lost from sight, unless the impacted tooth is fairly superficially placed. The only manner in which contact may be maintained with it is through the agency of some form of ligature wire, gold chain or elastic thread, which is attached to the eyelet before it is bonded to the tooth.

Since elastic thread can only be tied once, it is not recommended for an attachment that is not clearly visible and accessible in the mouth. Gold chain would appear to be unnecessarily sophisticated, although it is undoubtedly suitable and sufficiently strong for the purpose. The use of a stainless steel ligature is far easier from every point of view, and is readily at hand in the orthodontic and surgical operatory. Such a ligature is passed through the eyelet and twisted into a long braid with artery forceps before bonding is undertaken. The braided wire or pigtail hangs loosely in the eyelet until after bonding and resuturing have been completed, and it should be of sufficient substance for it to be rolled up into a loop that will not easily be unraveled by the application of the extrusive force. On the other hand, it must not be so thick that the effort that is needed to form the loop will seriously test the bond strength of the newly placed attachment. In practice, the use of a dead soft stainless steel ligature wire of 0.011'' or 0.012'' gauge is generally the most suitable.

It has been recommended that the pigtail be braided in such a way that each two or three turns of the braid are followed by a small loop, then two or three more turns, another loop, and so on. In this way, the braid comprises a convenient chain of loops, which may be shortened as necessary by cutting off the excess, while exploiting the loop closest to the gingival tissue (111). However, 'rolling up' the terminal loop of a simply twisted stainless steel ligature as the tooth progresses is simpler and 'user-friendly'.

4.7.4 Elastic Ties and Modules versus Auxiliary Springs

At first glance, elastic ties of one sort or another present the orthodontist with the most convenient means of applying light forces to a tooth, with a good range of action. However, their use is usually far more disappointing than one may initially realize.

The manufacturer's spool of elastic thread usually comes in the form of fine hollow tubing, which is easier to tie than a solid thread. Most orthodontists tie the thread with a simple knot that, when tying string, will not unravel. When tying elastomeric thread, however, the knot tends to loosen, and much of the original force of the tie will be lost in this loosening. When under tension, all the materials used to make this elastic thread suffer a high degree of force decay, which is very rapid and very significant. The force levels of chains of various lengths are known to decay to below the force required for tooth movement, in a period of between 1 and 3 weeks, depending upon the amount of tension initially applied (66, 93).

Naturally, a shorter piece of stretched elastic will have a very short range, and runs the risk of applying an initial excessive amount of pressure if the tie is good – or no effective pressure if the tie loosens. The immature periodontal membrane of the recently exposed tooth and the strength of its bonded attachment could be severely tested. In the case of an unerupted tooth close to the line of the arch, traction applied directly from its attachment to the archwire will generally be very inefficient, requiring frequent changes and producing only a very slow response. For all practical purposes, it is impossible to measure or control such a force.

It is prudent to use more distant sites from which to apply traction to the unerupted tooth, in order to include a greater length of elastic thread to increase the range of the traction force and thereby its effectiveness in moving the tooth over a longer period of time. To do this, the elastic thread needs to be stretched to the target area on the archwire, through the agency of a loop bent into the archwire at that point. The thread may then be tied back to the hook on the molar tube of the same side, with care being taken to insert a stop in the archwire, mesial to the tube, in order to prevent mesial movement of the molar.

As a general rule, elastic thread should be used as the go-between connecting the non-elastic steel pigtail to a similarly non-elastic and heavy archwire. If a lighter

archwire is used then the tie should be made with a steel ligature – the archwire providing the elastic displacement. In this event, however, the distortion of the archwire will bring about an alteration in its shape in both the horizontal and vertical planes, to produce unwanted change in the form of the dental arch and an uneven occlusal plane.

The use of both a flexible archwire and an elastic ligature is counterproductive, since the elasticity of the one that exerts the stronger force will be effectively neutralized and will offer no physical advantage over a steel ligature, while the displacement of the weaker element will be the only factor that is active in moving the teeth (88).

In general, orthodontists use elastic ligature to move teeth by first elongating the material and tying it between two dental elements. Once tied, a natural recoil is exerted along its long axis, pulling the dental elements towards one another. The amount of elasticity in this direction is limited and, as pointed out above, decays rapidly. However, the lateral displacement of an elongated elastic thread produces a potentially greater range of movement, within suitable orthodontic force levels, than does a longitudinal displacement. This principle may be applied to moving teeth that lie at a distance from the main arch more efficiently and with controlled and measurable forces.

Many authors have described another technique used to extrude impacted canines. The general principle is to tie an elastic force from the emerging tooth to a heavy wire engaged in adjacent teeth. Others eliminate the necessity of banding the teeth but use the same principle in placing a wire bonded to adjacent teeth from which to use the elastic traction. To prevent lingual tipping of the molar teeth and intrusion of the first premolars, these teeth are all splinted together with a heavy palatal bar soldered to stainless steel bands. Some clinicians also use intermaxillary elastics to exert the extrusive force on the canine from the lower teeth. Jacoby (51) described a fixed appliance, termed "ballista spring," which uses a spring engaged in the buccal tubes of the molar bands and first premolar. The impacted tooth is retracted by a spring that accumulates a continuous force from being twisted on its long axis. The necessary operation on the impacted tooth is simple and less traumatic. The force exerted on the tooth is vertical, without compressing the impacted tooth toward the adjacent roots. This force is well controlled and easily modified. By the lack of appliance on the front teeth

during a great part of the treatment, the esthetic side of the treatment is respected. Complicated impacted teeth in adults can be treated.

Given a little thought in the planning of their use, elastic ties, chains and modules are extremely helpful in many situations arising because of the presence of impacted teeth. However, properly designed springs, auxiliary to a heavy base arch, are usually more efficient, since their ability to deliver a measured and controlled force is good, the force decay is lower, the variety of metallic alloys available for spring fabrication is broad, and their range of action may be very wide and their direction accurate.

4.7.5 Magnets

Rare earth magnets were developed 40 years ago, but only more recently have they been developed to the point where their reduction in size, with the introduction of lanthanide alloys, has provided the possibility of applying suitable forces. Sandler et al. (84) have presented successful clinical results of the treatment of impacted teeth in humans.

The magnetic attracting force that exists between the two magnets is inversely proportional to the square of the distance between them. This means that a magnet sited on the appliance must be placed close to the magnet that has been bonded to the displaced tooth and that a grossly displaced tooth may require that the location of the appliance magnet be resited from time to time, in line with the progress of the tooth. The forces generated are centripetally orientated, and it is possible to design their application to move the unerupted tooth in all three planes of space from the very beginning and before the tooth erupts (101).

The notion that traction may be applied without the need to trail a wire through the soft tissues of the palate, appeals to Sandler and his co-workers. They speculate that this may improve the final periodontal condition of the teeth, since ‘eruption simulates a normal eruption process’. However, given that

(a) the tooth must nevertheless initially be exposed surgically,
(b) the magnet must be bonded to it,
(c) the flap must be replaced and healing must occur, and
(d) the tooth must then pass through the tissues with this relatively large

'backpack', this claim may be difficult to justify in practice.

The idea is indeed 'attractive' (83), but it is not a method that, at present, can unequivocally replace the more traditional and conventional methods described above (44, 48, 82). The use of magnets for impacted teeth is in its early developmental stages, and the methods that have been described appear rather clumsy and inconvenient (30). Their greatest disadvantage is the corrosion that occurs with their use in tissue and the, so far, unsuccessful attempts at their hermetic isolation (102). The use of magnets in this context and with the present state of the art offers no advantages over traditional methods, and provides little more than curiosity value.

4.8 PERIODONTAL HEALTH OF PALATALLY IMPACTED OR BUCCALY ECTOPIC MAXILLARY CANINES AFTER ORTHODONTIC TREATMENT

Periodontal evaluation is an important requisite for the patient prior to combined surgical/orthodontic treatment. Periodontal problems many times can be prevented by careful case planning and appropriate oral hygiene control. The management of impacted canines usually requires cooperation between oral surgery, orthodontics and periodontology. The orthodontic approach aims in moving the corresponding tooth into its correct position in the dental arch without causing periodontal problems. Optimal periodontal support is related to initial position of the impacted tooth as well as to the type of the surgical and orthodontic technique used.

Regarding the palatally impacted canines, their surgical exposure and alignment with open-surgical approach results to a significantly greater loss of attachment both on the buccal and palatal surfaces when compared to the control teeth, which erupted unaided (108, 110). According to Becker (12), this method will leave the tooth with a soft tissue deficiency and a long clinical crown, especially when it is placed deeply in the palatal mucosa.

Periodontal health may be also compromised when the closed-surgical exposure is performed. Woloshyn et al. (109) observed that the probing attachment level was increased and the crestal bone height was significantly lower in the impacted canines treated with this method. These findings agree also with the results of Becker et al. (4), in their study group of 23 patients with unilateral palatal impaction of a maxillary

canine. On the other hand, Crescini et al. (27), found no attachment loss, no recession and no significant differences in keratinized tissue width in a follow-up examination of eight cases with impacted canines treated with this method, when compared to the contralateral unaided erupted canines. A good gingival and periodontal status with slight differences between treated and untreated sides was also reported by Hansson and Rindler (45), in their follow-up study 1 to 18 years after completion of orthodontic treatment of unilateral palatally impacted maxillary canines; though, increased pocket depth and lower marginal bone level were registered. Caminiti et al. (25) reported also no gingival inflammation and no recession after forced eruption of 60 palatally impacted canines treated with this technique.

By comparing the open- and closed surgical exposure, it has been found that the open exposure causes more periodontal damage (loss of attachment and interdental bone height) than the closed one although the mean differences between the two techniques were small (107). Furthermore, Kohavi et al. (56) found a consistent significant loss of alveolar bone height on the mesial proximal surface of the exposed tooth with the amount of bone loss being greater if exposure is carried out to below of the cemento-enamel-junction. According to Becker (12), the full flap closure (close-surgical exposure technique) after attachment placement on the exposed tooth must be recommended over any other, because the tooth is then exposed with the minimum tissue removal and consequent surgical trauma, which in combination with appropriate orthodontic biomechanics will provide healthy mucogingival tissues and the best bone support. Becker based scientifically his recommendation on various clinical comparisons of surgical methods of exposure (4, 19, 27, 46, 56, 103, 108).

As far as the treatment of labially impacted canines concerned, it was found that, when compared to nonimpacted contralateral ones, their simple surgical exposure resulted to damaging effects on the periodontium (19, 95). Regarding the closed-eruption technique, it was observed that a reduced width of attached gingiva and an increased probing bone level of the uncovered teeth (103), while there have been also contradictory results (27). The comparison of the closed-eruption technique with the apically repositioned flap technique, Vermette et al. (103) revealed that teeth uncovered with the apically repositioned flap technique presented more un-esthetic sequelae than those uncovered with the closed-eruption technique.

5. MATERIALS AND METHODS

5.1 Criteria for Patient Selection

From the archive files of the Department of Orthodontics in the Dental Faculty of Marmara University and Dental Faculty of Yeditepe University, 15 patients who had unilateral palatally impacted canines and 15 patients who had unilateral buccally ectopic canines at the beginning of their orthodontic treatment were identified. All of these patients had completed their fixed orthodontic treatment and had their braces removed at least 6 months ago. Also they should have optimum oral hygiene and any systemic disease.

We had searched archieves of these 2 departments and found 52 patients. Thirty of these 52 patients, who met these criterias and accepted to come to the appointments were choosen. Twenty one of them were girls and 9 of them were boys. Mean age of the patients at the beginning of the treatment was 11.43 ± 1.45 years. Mean treatment duration was found to be 3.71 ± 1.32 years.

In the first group of patients palatally impacted canines had been exposed using a close approach (CA) technique with a minimal bone removal in the Department of Dental Surgery of Marmara University and Yeditepe University. Attachments had been bonded to the impacted canines at the time of surgical exposure (Figure 1, 2).

In the second group of patients who had buccaly ectopic maxillary canines, orthodontic treatment for alignment of these teeth were completed by conventional orthodontic techniques, with or without the extraction of permanent teeth. For the two of the buccaly ectopic canine patients, electrosurgery were done (Figure 3, 4).

Figure 1. Panoramic film of a palatally impacted canine patient before treatment

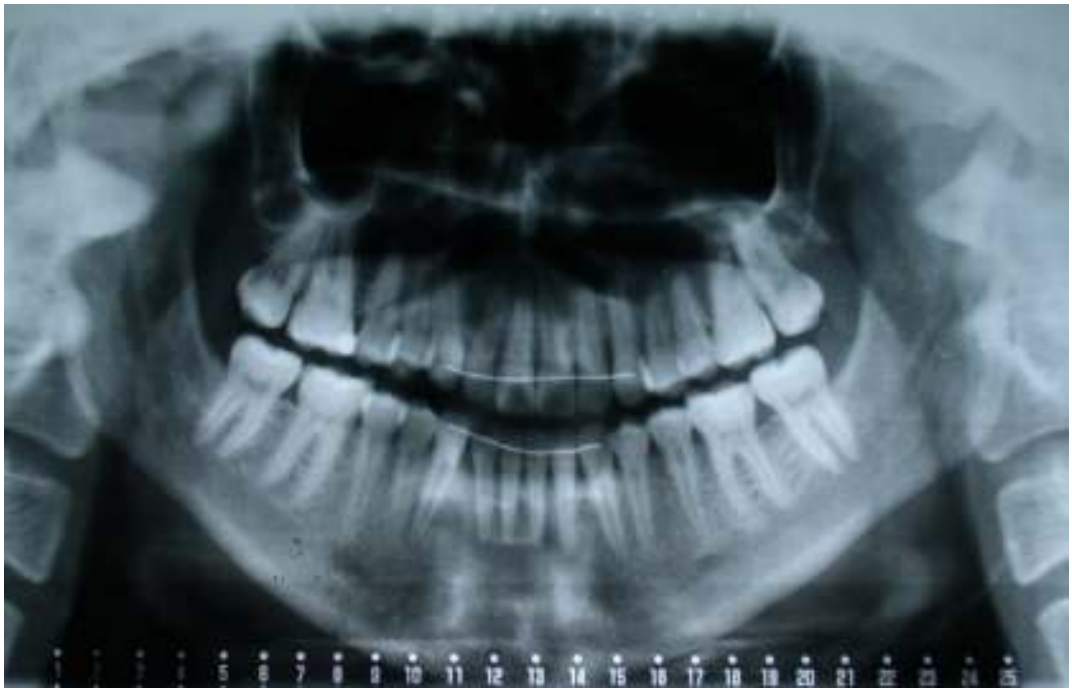

Figure 2. Panoramic film of a palatally impacted canine patient after treatment

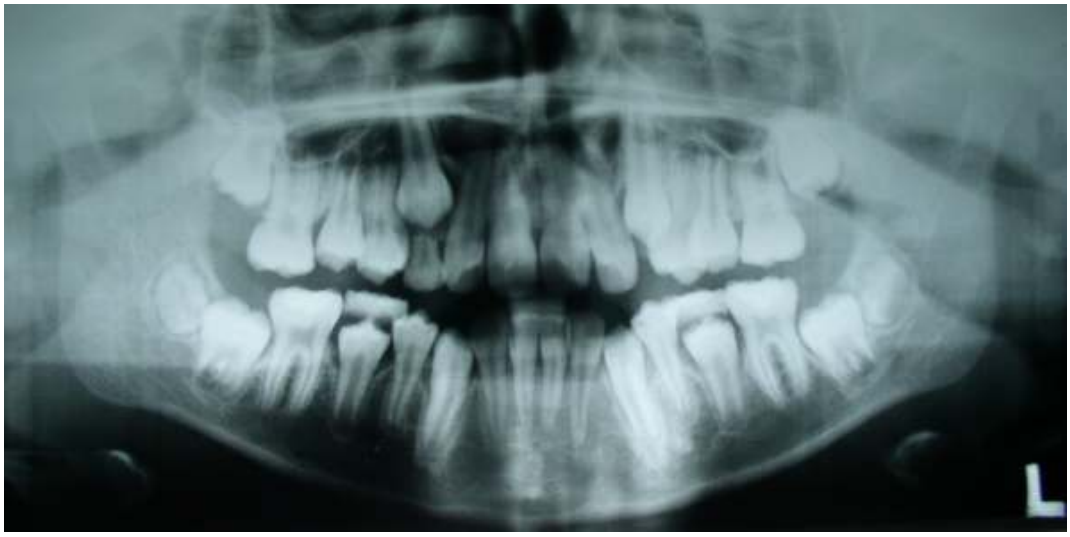

Figure 3. Panoramic film of a buccaly ectopic canine patient before treatment

Figure 4. Panoramic film of a buccaly ectopic canine patient after treatment

5.1.1 Patient Follow Up Form

Patient Name/ Surname:				
Age/ Sex:				
Phone Number:				
Mobile Number:				
Subscription Date:				
Plaque Index:				
	3		3	
	D	M	M	D
	P	B	B	P
Gingival Bleeding Index:				
	3		3	
	D	M	M	D
	P	B	B	P
Pocket Depth:				
	3		3	
	D	M	M	D
	P	B	B	P

Attached Gingival Width:				
	3		3	
Gingival Level:				
	3		3	
	P	B	B	P
Crown Length:				
	3		3	
Electric Pulp Testing Score:				
	3		3	
Bone Level:				
	3		3	
	D	M	M	D
Root Length:				
	3		3	

5.2 Methods

The collection of clinical data was made by recalling the patients in both groups to the orthodontic department of Marmara University and Yeditepe University, to evaluate their periodontal status clinically and radiographically. In both groups, the contralateral normally placed canines served as control (Figure 5, 6, 7, 8).

5.2.1 Clinical Evaluation

1- **Periodontal examination :** Following measurements were made on the impacted and ectopic canines and their contralateral controls in both groups to evaluate their periodontal health status :

   a) Plaque Index (PI) : The mesial, distal, buccal and palatinal surfaces were scored on a scale of 0 to 3, according to the method described by Silness and Löe (90).

   b) Gingival Bleeding Index (GBI) : The same surfaces were scored as for the plaque index on a scale of 0 to 3, according to the method of Löe and Silness (65).

   c) Pocket Depth (PD) : The depth of the mesial, distal, buccal and palatinal gingival pocket was measured as the distance from the free gingival margin to the bottom of the pocket with a standard periodontal probe (Figure 9, 10, 11).

   d) Attached Gingival Width (AGW) : The width of attached gingiva was measured by subtracting the pocket depth from the distance between the gingival margin and the mucogingival junction.

   e) Gingival Level (GL) : Gingival level on the buccal and palatinal aspects of study canines was measured with a divider from the most apical extent of the cementoenamel junction to the most apical extent of the gingival margin.

   f) Crown Length (CL) : Clinical crown length was measured as the distance between the canine cusp tip and most apical extent of the gingival margin.

2- Electric Pulp Testing Score (EPTS) : Tooth vitality was assessed with Parkell Pulp Vitality Tester, grading from 1 to 10 (10 being nonvital). Electric pulp

testing of the teeth was carried out at the Department of Oral Diagnosis and Radiology at Marmara University and Yeditepe University (Figure 12, 13).

5.2.2 Radiographic Evaluation

For measurements of bone level and root resorption, two periapical radiographs were obtained on either side of each individual, using a long-cone paralleling technique. All radiographs were scanned and transferred to computer. The measurements of these images were done by Dental Studio NX 2006 Version 6.0 software. a) Bone level was measured by calipers as the distance from the cementoenamel junction (CEJ) to the alveolar crest both on the mesial and distal sides (Figure 14). b)Root length was measured as the distance from a line connecting the mesial and distal CEJ to the root apex using a ruler (Figure 15).

Periapical radiographs were obtained at the Department of Oral Diagnosis and Radiology at Marmara University and Yeditepe University.

5.3 Reliability of the Method

In order to determine operator reliability and reproducibility, all the bone level and root length measurements of 60 teeth were repeated 2 weeks later by the same observer. Correlation between these two sets of measurements was assessed with Pearson Correlation Analysis.

5.4 Statistical Method

The Paired-Samples T Test was used to compare parametric data (pocket depth, attached gingival width, gingival level, crown length, bone level and root length) , while the Wilcoxon Signed Ranks Test was applied to compare nonparametric data (plaque index, gingival bleeding index and electric pulp testing score) between the ectopic canines and their contralateral controls. To make comparisons between palatally impacted and buccaly ectopic canines, Mann-Whitney U Test was used for nonparametric data and Unpaired-Samples T Test was used for parametric data. Level of significance was selected as $p<0.05$ for all tests. All statistical tests were made using the SPSS 12.0 (Statistical Software Package for Social Sciences SPSS Inc., Chicago, II, US).

Figure 5. Intraoral pretreatment photos of a palatally impacted canine

Figure 6. Intraoral posttreatment photos

Figure 7. Intraoral pretreatment photos of a buccaly ectopic canine

Figure 8. Intraoral posttreatment photos

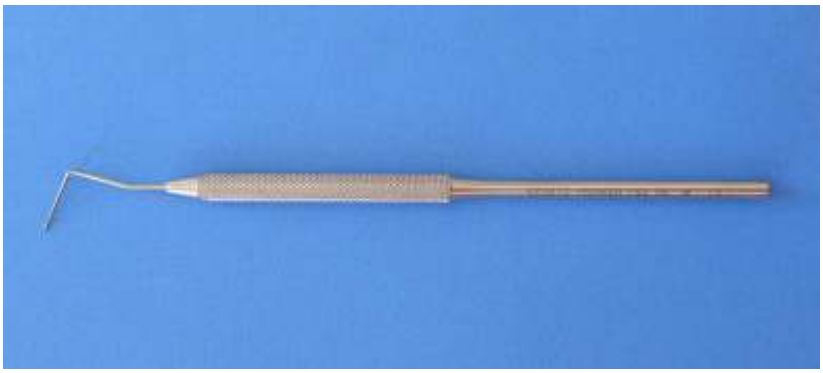

Figure 9. Periodontal Probe

Figure 10. Before measurement

Figure 11. During measurement

Figure 12. Pulp Vitality Tester

Figure 13. During procedure

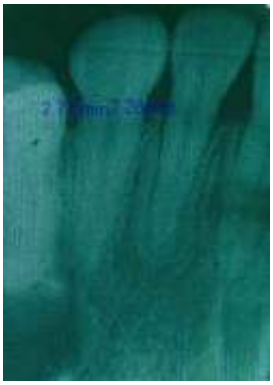

Figure 14. Bone level

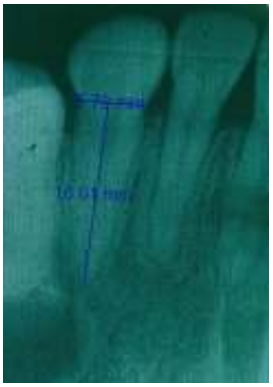

Figure 15. Root length

6. RESULTS

6.1 Reliability of the Method

In order to evaluate method error, all the bone level and root length measurements of 60 teeth were repeated 2 weeks later by the same observer. The correlation between the first and second measurements was established to be high. Findings suggest that bone level and root length measurements are reliable ($r = 1.000$; $p = 0,01$).

6.2 Patient Examination Findings

6.2.1 Comparison of the All Ectopic Canines (Buccal and Palatal) And Their Contralateral Controls

Thirty unilateral buccaly ectopic / palatally impacted canines and their contralateral controls were compared with respect to periodontal health and tooth sensitivity. The parametric variables included pocket depth, attached gingival width, gingival level, crown length, bone level and root length. The nonparametric variables were plaque index, gingival bleeding index and electric pulp testing score. Comparison of the buccaly ectopic / palatally impacted canines and their contralaterals showed statistically significant differences in plaque index, gingival bleeding index, pocket depth, attached gingival width, gingival level, crown length, electric pulp testing scores and bone level.

All ectopic canines had increased plaque index ($p<0.01$), increased gingival bleeding index ($p<0.01$), greater pocket depths ($p<0.001$), reduced attached gingival width ($p<0.01$), higher gingival levels ($p<0.001$), increased crown lengths ($p<0.001$), higher electric pulp testing scores ($p<0.001$) and reduced bone levels ($p<0.01$) compared to their contralaterals (Table 1).

Table 1: Comparison of the all ectopic canines and their contralaterals after orthodontic treatment.

Variable	Ectopic (N=30)		Contralateral (N=30)		Difference		
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	p
Plaque index	1,28	0,53	0,78	0,52	1,28	0,56	0,001
Gingival bleeding index	0,58	0,54	0,21	0,37	0,37	0,44	0,001
Pocket Depth (mm)	1,63	0,26	1,36	0,38	0,28	0,32	0,000
Attached Gingival width (mm)	3,03	0,76	3,53	0,94	-0,50	0,86	0,003
Gingival level (mm)	1,08	0,77	0,50	0,51	0,58	0,56	0,000
Crown length (mm)	10,33	10,33	9,43	1,07	0,90	1,06	0,000
Electric pulp testing score	5,30	1,70	4,57	1,61	0,73	0,64	0,000
Bone level (mm)	1,36	0,26	1,22	0,27	0,14	0,21	0,001
Root length (mm)	10,71	0,95	10,89	0,79	-0,18	0,73	0,184

N: Number of the patients; p: Two-tailed significance

6.2.2 Comparison of the Palatally Impacted Canines and Their Contralateral Controls

Fifteen unilateral palatally impacted canines and their contralateral controls were compared. Comparison of the palatally impacted canines and their contralaterals showed statistically significant differences in pocket depth, gingival level, electric pulp testing scores and bone level.

Palatally impacted canines had greater pocket depths ($p<0.01$), higher gingival levels ($p<0.01$), higher electric pulp testing scores ($p<0.01$) and reduced bone levels ($p<0.01$) compared to their contralaterals (Table 2).

Table 2: Comparison of the palatally impacted canines and their contralateral after orthodontic treatment.

	Ectopic (N=15)		Contralateral (N=15)		Difference		
Variable	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	P
Plaque index	1,17	0,70	0,80	0,56	0,37	0,61	0,05
Gingival bleeding index	0,45	0,61	0,22	0,39	0,23	0,45	0,073
Pocket Depth (mm)	1,63	0,33	1,25	0,51	0,38	0,40	0,002
Attached Gingival width (mm)	3,20	0,86	3,13	0,99	0,07	0,88	0,774
Gingival level (mm)	0,97	0,79	0,53	0,52	0,43	0,59	0,013
Crown length (mm)	10,27	0,46	9,73	1,10	0,53	1,06	0,072
Electric pulp testing score	6,00	1,89	5,27	1,83	0,73	0,80	0,008
Bone level (mm)	1,51	0,18	1,29	0,27	0,22	0,21	0,001
Root length (mm)	10,63	1,02	10,81	0,82	-0,18	0,83	0,407

N: Number of the patients; p: Two-tailed significance;

6.2.3 Comparison of the Buccaly Ectopic Canines and Their Contralateral Controls

Fifteen unilateral buccaly ectopic canines and their contralateral controls were compared. Comparison of the buccaly ectopic canines and their contralaterals showed statistically significant differences in plaque index, gingival bleeding index, pocket depth, attached gingival width, gingival level, crown length and electric pulp testing scores.

Buccaly ectopic canines had increased plaque index ($p<0.01$), increased gingival bleeding index ($p<0.01$) , greater pocket depths ($p<0.01$), reduced attached gingival width ($p<0.001$) , higher gingival levels ($p<0.001$), increased crown lengths ($p<0.001$) and higher electric pulp testing scores ($p< 0.01$) compared to their contralaterals. Bone level of the buccaly ectopic canines was reduced as well but this reduction was not statistically significant (Table 3).

Table 3: Comparison of the buccaly ectopic canines and their contralaterals after orthodontic treatment.

	Ectopic (N=15)		Contralateral (N=15)		Difference		
Variable	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	P
Plaque index	1,38	0,28	0,77	0,50	0,62	0,49	0,002
Gingival bleeding index	0,70	0,44	0,20	0,37	0,50	0,40	0,003
Pocket Depth (mm)	1,63	0,19	1,47	0,13	0,17	0,15	0,001
Attached Gingival width (mm)	2,87	0,64	3,93	0,70	-1,07	0,26	0,000
Gingival level (mm)	1,20	0,75	0,47	0,52	0,73	0,50	0,000
Crown length (mm)	10,40	0,83	9,13	0,99	1,27	0,96	0,000
Electric pulp testing score	4,60	1,18	3,87	0,99	0,73	0,46	0,001
Bone level (mm)	1,22	0,26	1,15	0,27	0,07	0,19	0,198
Root length (mm)	10,78	0,90	10,96	0,77	-0,18	0,64	0,298

N: Number of the patients; p: Two-tailed significance;

6.2.4 Comparison of the Buccaly Ectopic and Palatally Impacted Canines

Unilateral buccaly ectopic canines of 15 patients were compared with unilateral palatally impacted canines of 15 other patients, with respect to periodontal health and tooth sensitivity. Comparison of the buccaly ectopic and palatally impacted canines showed statistically significant differences in electric pulp testing scores and bone level.

Buccaly ectopic canines had lower electric pulp testing scores ((p<0.01) and higher bone levels (p<0.01) compared to palatally impacted canines (Table 4).

Table 4: Comparison of the buccaly ectopic and palatally impacted canines after orthodontic treatment.

	Buccal (N=15)		Palatal (N=15)		Difference		
Variable	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	p
Plaque index	1,38	0,28	1,17	0,70	0,22	0,75	0,133
Gingival bleeding index	0,70	0,44	0,45	0,61	0,25	0,67	0,104
Pocket Depth (mm)	1,63	0,19	1,63	0,33	0,00	0,40	1
Attached Gingival width (mm)	2,87	0,64	3,20	0,86	-0,33	1,05	0,239
Gingival level (mm)	1,20	0,75	0,97	0,79	0,23	1,12	0,414
Crown length (mm)	10,40	0,83	10,27	0,46	0,13	1,06	0,59
Electric pulp testing score	4,60	1,18	6,00	1,89	-1,40	2,26	0,035
Bone level (mm)	1,22	0,26	1,51	0,18	-0,29	0,29	0,001
Root length (mm)	10,78	0,90	10,63	1,02	0,16	1,49	0,657

N: Number of the patients; p: Two-tailed significance;

7. DISCUSSION

7.1 Discussion of the aim

The orthodontic treatment aims in moving the corresponding tooth into its correct position in the dental arch without causing periodontal problems and tooth vitality loss. But the periodontal condition and sensitivity of treated impacted canines were reported to be affected from the surgical and orthodontic procedures used.

There are studies (4, 41, 56, 107, 108) which have previously illustrated the potential periodontal problems associated with surgical exposure and orthodontic alignment of ectopic canines. However, it must be remembered that orthodontic treatment itself carries a risk of tooth morbidity in the form of alveolar bone loss, root shortening and loss of gingival attachment but also during the exposure of impacted teeth additional periodontal problems occurred (64). In both situations, the role of increased difficulty in maintaining adequate oral hygiene during appliance therapy may be significant.

Kohavi et al. (55), found that during orthodontic treatment of palatally impacted canines loss of bone level occurred. They divided the patients into two groups; light and heavy exposure groups. For the bone level values, there were significant differences. For the distal bone level and for the total (mesial and distal) bone level, statistically significant bone loss was greater for the "heavy" forces than for the "light" forces.

In another study, Kohavi, Zilbermann and Becker (57) published the results of a periodontal study of 29 patients who had completed orthodontic treatment to resolve buccal displacement of maxillary canine teeth. The most obvious finding was the statistically significant difference between the amount of attached gingiva found on the treated canines and that of the controls. The control sides had over 1 mm more attached gingiva than the treated teeth.

In a later publication with 23 patients, Becker et al. (4) examined the pocket depths of the palatally ectopic canines and compared them with the contralateral ones. The mean pocket depth was found to be significantly greater on the previously ectopic canine (2.53 mm) compared with the contralateral canine (2.17 mm).

Wisth et al. (107) compared the periodontal status between treated palatally impacted canines which had been moved by means of orthodontic forces and the contralateral control ones, which had erupted unaided and found that the pocket on the distal surface was significantly deeper in the treated impacted canines. Both the buccal and the palatal surfaces of the previously impacted canines displayed significantly greater loss of attachment than the control teeth did. The significant difference between the loss of attachment on the buccal surface of the previously impacted canines and the control teeth, confirms the findings of Zachrisson and Alnaes (110).

On the other hand, Boyd (19) observed that the comparison between the palatally impacted canines treated with the one-step approach and direct bonding and the contralateral non-impacted ones, revealed no clinically significant differences in the mean values of loss of attachment. The same finding was observed in all six tooth sites (mesio-lingual, lingual, disto-lingual, disto-labial, labial, meso-labial).

Crescini et al. (27) reported on the periodontal effects of the treatment of the infra-osseous buccaly ectopic canines. They found no attachment loss and no recession at the end of active treatment and after three years follow-up. In addition, no significant differences were observed in the width of keratinized tissue between the surgically uncovered and the contralateral spontaneous erupted canines.

Regarding the periodontal conditions following use of surgical exposure techniques of buccaly ectopic canines, Tegsjö et al. (95) observed two groups of patients. One of them was treated group and the other one was non-treated group. They found no significant differences in the periodontal status between treated canines and the non-treated contralaterals including the gingival margin and bone loss variables.

In the literature there are only a few studies about vitality of impacted maxillary canines after active orthodontic treatment. Blair (18) reported on the tooth vitality loss of the treatment of palatally impacted maxillary canines. Tooth vitality was assessed with an electric pulp tester, grading from 1 to 10 (10 being nonvital).The slightly lower response of control group in electric pulp vitality in comparison with the exposed canines was not significant and was within the limits of the equipment used. In another study, D'Amico et al. (29) followed up a total of 61 children who had maxillary canines impacted for a mean of 3.5 years after treatment to evaluate the long-term results of the treatments. In most of the children, the impacted maxillary canines had been surgically

exposed and treated with fixed orthodontic appliances. As a result they found that the vital response of 2 canines was reduced. So both orthodontic and surgical procedures can influence sensitivity of the treated impacted teeth.

The aim of our study was to assess the periodontal status and sensitivity of the palatally impacted and buccaly ectopic canines after orthodontic treatment and compare them with the contralateral canines which served as control teeth and also with each other. When we look at the previous studies in the literature, we see that there is conflicting evidence on how the periodontal condition and vitality of the impacted canines were affected by treatment procedures. By determining to which extent we had been successful in preserving the periodontal health and sensitivity of our treated ectopic canine cases, we will have a chance to evaluate our treatment strategies.

7.2 Discussion of the materials and method

All of the 30 cases investigated were selected from the archive files of the Department of Orthodontics in the Dental Faculty of Marmara University and Dental Faculty of Yeditepe University. Fifteen patients were identified who had unilateral palatally impacted canine and 15 patients who had unilateral buccally ectopic canine at the beginning of their orthodontic treatment.

In order to be able to include a sufficient number of patients in the study groups , we examined the archieve files of two separate departments which were Department of Orthodontics in the Dental Faculty of Marmara University and Dental Faculty of Yeditepe University.

In the first group of patients palatally impacted canines had been exposed using a closed-surgical approach (CA) technique with minimal bone removal. When comparing the open- and closed- surgical exposure, it has been found that the open exposure caused more periodontal damage (loss of attachment and interdental bone height) than the closed one (107). It can be said that the periodontal condition of treated impacted canines is almost always affected, independent of the surgical or orthodontic procedures used. However, it seems that less damaging effects on the periodontium should be anticipated when using the closed-surgical exposure techniques, which involve raising of a surgical flap, bonding of an attachment and finally resuturing of the

flap to its original position. So our palatally impacted canine group had been selected among those patients whose canines were exposed with this technique in order to eliminate more side effects of the open-surgical exposure.

It is recommended that surgical procedures designed to expose buccaly ectopic canines erupting through alveolar mucosa should simultaneously provide a band of attached gingiva to the exposed tooth. Otherwise, improper soft-tissue management may lead to mucogingival recession and loss of alveolar bone. The creation and preservation of a functional band of attached gingiva should be an important objective in the management of buccaly ectopic canines.

However, before a decision is made to surgically increase the gingival zone, we should carefully consider the biological events that take place during the development of the dentition. In the child the gingival dimensions will increase because of growth in the alveolar process and changed position of the teeth in the alveolar process. Longitudinally monitoring of the gingival dimensions at the facial aspect of anterior teeth in the developing dentition has shown that a significant increase of the gingival height will take place. Also, the spontaneous change of the tooth position in the bucco-lingual direction that often occurs during the development, will affect the gingival height. A more lingual positioning of the tooth results in an increase of the gingival height, whereas the opposite will be the case when a tooth moves to a more facial position in the alveolar process (105).

When referring a patient for surgical exposure of a buccaly ectopic canine, the orthodontist should evaluate 4 criteria to determine the correct method for uncovering the tooth. First, the labiolingual position of the ectopic canine crown should be assessed. If the tooth is impacted labially, then any of the 3 techniques (excisional approach, apically positioned flap technique, closed-flap eruption technique) could be used, because generally there is little if any bone covering the crown of the impacted canine. However, if the tooth is impacted in the center of the alveolus, an excisional approach and an apically positioned flap are generally more difficult to perform, because extensive bone might need to be removed from the labial surface of the crown. The second criterion to evaluate is the vertical position of the tooth relative to the mucogingival junction. The orthodontist should create enough space for the ectopic canine, if the canine does not erupted spontaneously, the surgeon should expose the

crown surgically. If most of the canine crown is positioned coronal to the mucogingival junction, any of the 3 techniques can be used to uncover the tooth. However, if the canine crown were positioned apical to the mucogingival junction, an excisional technique would be inappropriate, because it would not result in any gingiva over the labial surface of the tooth after it had erupted. In addition, if the crown were positioned significantly apical to the mucogingival junction, an apically positioned flap would also be inappropriate. In the latter situation, a closed eruption technique will provide adequate gingiva over the crown.

The third criterion to evaluate is the amount of gingiva in the area of the impacted canine. If there were insufficient gingiva in the area of the canine, the only technique that predictably would produce more gingiva is an apically positioned flap. However, if there were sufficient gingiva to provide at least 2 to 3 mm of attached gingiva over the canine crown after it had been erupted, any of the 3 techniques could be used. The fourth and final criterion to evaluate is the mesiodistal position of the canine crown. If the crown were positioned mesially and over the root of the lateral incisor, it could be difficult to move the tooth through the alveolus unless it was completely exposed with an apically positioned flap. In this latter situation, closed eruption or excisional uncovering generally would not be recommended (59).

In the second group of patients who had buccaly ectopic maxillary canines, orthodontic treatment for alignment of these teeth were completed by conventional orthodontic techniques. After enough space was created for ectopic canines by the clinician, the teeth were erupted spontaneously. Since the position of the two canines were coronal to the mucogingival junction, and they didn't erupt spontaneously, only in these cases gingival tissue around the crown was removed with electro surgery in order to place a bracket; the remaining of the group was treated without any surgical procedure. In two patients, who had electro surgery, no bone was removed around the crown, only gingival tissue was removed to open a window for bracket placement.

In order to assess the periodontal health of treated ectopic canines, Kohavi, Becker and Zilberman (55) used 5 periodontal parameters, Tiziano et al. (28) used 2 parameters, D'Amico et al. (29) used 3 parameters. In this study 6 periodontal parameters were used in order to appraise periodontal health of the treated canines.

These were choosen among the most commonly used periodontal parameters so as to cover all dental and gingival landmarks. Many of the authors were used 2, 3, 4 or 5 of them.

Our study was a cross-sectional study. All the patients were archieve patients and it was not very feasible to call and ask them to come to the clinic for repeated measurements. Obviously, it is much easier and quicker to do a cross-sectional study, gathering data once for any individual rather than spending years on a study in which the same individuals were measured repeatedly. On the other hand, if this study was longitudinal, it could be efficient in the sense that a great deal of information related to the changes in the periodontal health of the ectopic canines during and after the treatment period could be followed. In addition, the longitudinal data highlight individual variations.

These 30 archieve patients were selected among the ones whose oral hygiene was good and who had no systemic disease. Since we are dealing with periodontal indices, if the patients involved presented with poor oral hygiene during the study or if they had a systemic disease like diabetes our measurements would be compromised.

In our study, we measured the bone loss on periapical radiographs. In the literature many of the authors used these films as well like Kokich (58), Kohavi, Becker and Zilberman (55), Woloshyn et al. (109), Hansson and Rindler (45), Becker et al. (10).

7.3 Discussion of the results

In our study, first we compared all ectopic (buccal and palatal) canines with their contralateral controls. In palatally impacted canine group, patients were treated with closed-surgical exposure technique, and in buccaly ectopic canine group, patients didn't require any surgical interventation except for 2 patients who had undergone electro surgery procedure. In order to account for any differences related to different treatment methods, we preferred to assess buccaly ectopic and palatally impacted canines separately as well. We compared buccally ectopic canines with their contralateral controls; and palatally impacted canines with their contralateral controls.

All ectopic canines had increased plaque index ($p<0.01$), increased gingival bleeding index ($p<0.01$), greater pocket depths ($p<0.001$), reduced attached gingival width ($p<0.01$), higher gingival levels ($p<0.001$), increased crown lengths ($p<0.001$), higher electric pulp testing scores ($p<0.001$) and reduced bone levels ($p<0.01$) compared to their contralaterals.

In the literature, Woloshyn et al. (109) observed greater pocket depths and the crestal bone height was significantly lower in the impacted canines compared to contralateral controls. On the other hand, Crescini et al. (27), found no attachment loss, no recession and no significant differences in keratinized tissue width in a follow-up examination of eight cases with impacted canines when compared to the contralateral canines.

In a recent Canadian study (25) of both palatally impacted and buccaly ectopic canines a group of researchers observed 54 patients with 82 impacted canines for 18-30 months after surgery. The 60 palatally impacted canines all utilized the closed eruption technique, and the 22 labially displaced teeth employed either an apically repositioned flap or closed eruption, depending on the initial position of the canine. All of the 82 teeth were successfully brought into occlusion. The only complications included 2 palatal and 1 labial canine debonding during treatment. Clinically, there were no cases of infection, eruption failure, ankylosis, gingival inflamation or gingival recession once complete eruption was achieved.

Palatally impacted canines had greater pocket depths ($p<0.01$), higher gingival levels ($p<0.01$), higher electric pulp testing scores ($p<0.01$) and reduced bone levels ($p<0.01$) compared to their contralaterals.

The results of Burden et al. (24), in their study group of 18 patients with unilateral palatal impaction of a maxillary canine were greater pocket depths and reduced bone levels which are similar to our results. A good gingival and periodontal status with slight differences between treated and untreated sides was reported by Hansson and Rindler (45), in their follow-up study 1 to 18 years after completion of orthodontic treatment of unilateral palatally impacted maxillary canines; though, increased pocket depth and lower marginal bone level were registered. Caminiti et al. (25) reported also no gingival inflammation and no recession after forced eruption of 60 palatally impacted canines.

Since our study was a retrospective study, it was not possible to obtain sound information on how much bone was removed during the surgical procedure. For sure the volume of bone removal is a very important variable influencing long-term periodontal health. The increases in the pocket depth and gingival level and decrease in the bone level of the palatally impacted canines after treatment may be related to the more extensive bone removal during the closed flap surgical approach. So coordination between the orthodontist and surgeon is very important when deciding the amount of bone removal. Also palatally impacted canines showed higher electric pulp testing scores. In the literature there are only a few studies about vitality of impacted maxillary canines after active orthodontic treatment and they found slight differences between treated and nontreated groups. The authors reported that sensitivity of these teeth were influenced from both orthodontic and surgical procedures applied. In our study, the long treatment duration, in addition to the orthodontic forces applied to these teeth might have influenced tooth vitality.

Buccaly ectopic canines had increased plaque index ($p<0.01$), increased gingival bleeding index ($p<0.01$), greater pocket depths ($p<0.01$), reduced attached gingival width ($p<0.001$), higher gingival levels ($p<0.001$), increased crown lengths ($p<0.001$) and higher electric pulp testing scores ($p< 0.01$) compared to their contralaterals.

As far as the treatment of buccaly ectopic canines is concerned, it was found that, when compared to nonimpacted contralateral ones, these teeth underwent more periodontal damage. According to Kohavi, Zilberman and Becker (57), the mean value for the attached gingiva was significantly different, with that of the treated teeth being 3.2 mm and that of the unaffected side 4.5 mm, in other words gingival width was reduced, in parallelism with our results. In Vermette et al.'s study (103), reduced width of attached gingiva and reduced bone levels of treated buccally ectopic canines compared to their contralaterals were observed. In our study we also found that bone level of the buccaly ectopic canines was reduced as well but this reduction was not statistically significant. On the other hand, Tegsjö et al. (95) found no significant differences on the periodontal status between treated impacted canines and the non-treated controls.

Our study results showed that, the width of the attached gingiva of treated canines was reduced. Attached gingival level of previously ectopic canines is very important for the periodontal health. A reduced amount of attached gingiva is reported to make the periodontal tissues more prone to inflammation (57, 59). The patient can maintain tooth brushing properly if the level of attached gingiva is normal. The reduction in the width of attached gingiva in our study may have been responsible for the increase in the gingival bleeding index. This inflammation may have lead to the increase in pocket depth and the decrease in the bone level. The higher plaque index values may have contributed to this process as well.

It has been noted from a number of case reports, that if a tooth is erupting in a facial position through the alveolar mucosa, no gingiva will form adjacent to the tooth surface. The fact that a zone of gingiva invariably regenerates after surgical removal of the entire portion of this tissue, seems to be contradictory to the observation that no gingiva is formed when the tooth spontaneously erupts through the alveolar mucosa. A likely explanation of this contradiction regarding the establishment of a gingival zone may be that, when the tooth during the eruption penetrates into the oral cavity, the reduced enamel epithelium and the epithelium of the alveolar mucosa fuse at the edge of the tooth. This means that no wounding of the connective tissue occurs and consequently, no granulation tissue formation can take place originating from the periodontal membrane. The marginal soft tissue on the facial aspect of the erupting tooth will therefore be composed of the loose connective tissue of the alveolar mucosa and covered by a nonkeratinized epithelium. If, on the other hand, a wound is created that allows the formation of a granulation tissue derived from the periodontal membrane, a zone of gingiva will be formed during healing (105).

The understanding of these biological concepts is of importance from a treatment point of view. If a tooth has an erupting position which may result in the positioning of its facial aspect within the alveolar mucosa, one should consider the possibility of surgically uncovering the tooth before it erupts through the mucosa. Such a treatment approach will establish a proper collagen-rich, keratinized border tissue around the tooth and will prevent the development of a potential mucogingival problem. Furthermore, taking into account the fact that the gingival dimensions will increase because of growth in the alveolar process and that teeth will often change their position

in a bucco-lingual direction in the developing dentition, mucogingival problems such as recession type defects will often be eliminated spontaneously in the growing child, provided adequate plaque control is established and maintained. Consequently, reparative surgical treatment of recession type defects in the developing dentition may not be necessary and should therefore be postponed until growth is completed (105).

The result of comparison of the buccaly ectopic and palatally impacted canines was that buccaly ectopic canines had lower electric pulp testing scores (($p<0.01$) and higher bone levels ($p<0.01$) compared to palatally impacted canines. The shorter treatment duration of buccaly ectopic canines and the fact that there was no need for bone removal during their treatment period might have been accounted for this difference.

8. CONCLUSION

1) All ectopic canines had increased plaque index and gingival bleeding index values, greater pocket depths, reduced attached gingival width, higher gingival levels, increased crown lengths, higher electric pulp testing scores and reduced bone levels compared to their contralaterals.

2) Palatally impacted canines had greater pocket depths, higher gingival levels, higher electric pulp testing scores and reduced bone levels compared to their contralaterals.

3) Buccaly ectopic canines had increased plaque index and gingival bleeding index values, greater pocket depths, reduced attached gingival width, higher gingival levels, increased crown lengths and higher electric pulp testing scores compared to their contralaterals.

4) Buccaly ectopic canines had lower electric pulp testing scores and higher bone levels compared to palatally impacted canines.

9. REFERENCES

1. Anerud A. (1970). The effect of preventive measures upon oral hygiene and periodontal health. Universitetsforlaget, Oslo.
2. Artun J, Osterberg SK, Joondeph DR. (1986). Long-term periodontal status of labially erupted canines following orthodontic treatment. J. Clin. Periodontol, 13: 856-861.
3. Ash AS. (1957). Orthodontic significance of anomalies of tooth eruption. Am. J. Orthod, 43: 559-576.
4. Becker A, Kohavi D, Zilberman Y. (1983). Periodontal status following the alignment of palatally impacted canine teeth. Am. J. Orthod, 84: 332-336.
5. Becker A, Shpack N, Shteyer A. (1996). Attachment bonding to impacted teeth at the time of surgical exposure. Eur. J. Orthod, 18: 457-463.
6. Becker A, Smith P, Behar R. (1981). The incidence of anomalous lateral incisors in relation to palatally displaced cuspids. Angle Orthod, 51: 24-29.
7. Becker A, Zilberman Y, Tsur B. (1984). Root length of lateral incisors adjacent to palatally-displaced maxillary cuspids. Angle Orthod, 54: 218-225.
8. Becker A, Zilberman Y. (1975). A combined fixed-removable approach to the treatment of impacted maxillary canines. J. Clin. Orthod, 9: 162-169.
9. Becker A, Zilberman Y. (1978). The palatally impacted canine. Am. J. Orthod, 74: 422-429.
10. Becker A. (1993). Ectopic eruption of maxillary canines. Eur. J. Orthod, 15: 425-430.
11. Becker A. (1984). Etiology of maxillary canine impactions. Am. J. Orthod, 86: 437-438.
12. Becker A. (1998). The Orthodontic Treatment Of Impacted Teeth. Martin Dunitz Ltd, London.
13. Beckwith RF, Ackerman RJ, Cobb CM, Tira DE. (1999). An evaluation of factors affecting duration of orthodontic treatment. Am. J. Orthod. Dentofac. Orthop, 115: 439-447.
14. Bishara SE, Kommer DD, Mc Neil MH, Montagana LN, Oesteler LJ, Youngquist HW. (1976). Management of impacted canines. Am. J. Orthod, 69: 371-387.

15. Bishara SE, Kommer DD, McNeil MH, Montagano LN, Oesterle LJ, Youngquist HW. (1976). Management of impacted teeth. Am. J. Orthod, 69: 371-387.
16. Bishara SE. (1998). Clinical management of impacted maxillary canines. Semin. Orthod, 4: 87-98.
17. Bishara SE. (1992). Impacted maxillary canines. Am. J. Orthod. Dentofacial Orthop, 101: 159-71.
18. Blair GS, Hobson RS, Leggat TG. (1998). Posttreatment assessment of surgically exposed and orthodontically aligned impacted maxillary canines. Am. J. Orthod. Dentofac. Orthop, 113: 329-332.
19. Boyd RL. (1984). Clinical assesment of injuries in orthodontic movement of impacted teeth. II. Surgical recommendations. Am. J. Orthod, 86: 407-418.
20. Boyd RL. (1982). Clinical assessment of injuries in orthodontic movement of impacted teeth. I. Methods of attachment. Am. J. Orthod, 82: 478-486.
21. 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, 8: 12-16.
22. Brin I, Solomon Y, Zilberman Y. (1993). Trauma as a possible etiologic factor in maxillary canine impaction. Am. J. Orthod. Dentofac. Orthop, 104: 132-137.
23. Broadbent BH. (1941). Ontogenic development of occlusion. Angle Orthod, 11: 223-241.
24. Burden DJ, Mullally BH, Robinson SN. (1999). Palatally ectopic canines: Closed eruption versus open eruption. Am. J. Orthod. Dentofac. Orthop, 115: 634-639.
25. Caminiti MF, Sander GKB, Giambattistini C, Tompson B. (1998). Outcomes of the surgical exposure, bonding and eruption of 82 impacted maxillary canines. J. Can. Dent. Assoc, 64: 572-4, 576-9.
26. Clark D. (1971). The management of impacted canines: free physiologic eruption. J. Am. Dent. Assoc, 82: 836-840.
27. Crescini A, Clauser C, Giorgetti R, Cortellini P, Pini Prato GP. (1994). Tunnel traction of infraosseous impacted maxillary canines. A three year periodontal follow-up. Am. J. Orthod. Dentofac. Orthop, 105: 61-72.
28. Crescini A, Nieri M, Buti J, Baccetti T, Prato G. (2007). Orthodontic and periodontal outcomes of treated impacted maxillary canines. Angle Orthod, 77:

571-577.

29. D'Amico R, Bjerklin K, Kurol J, Falahat B. (2003). Long-term results of orthodontic treatment of impacted maxillary canines. Angle Orthod, 73: 231-238.
30. Darendereliler MA, Friedli JM. (1994). Treatment of an impacted canine with magnets. J. Clin. Orthod, 28: 639-643.
31. Dewel BF. (1967). Clinical observations on the axial inclination of teeth. Am. J. Orthod, 35: 98-115.
32. Ericson S, Kurol J. (1988). Early treatment of palatally erupting maxillary canines by extraction of the primary canines. Eur. J. Orthod, 10: 283-295.
33. Ericson S, Kurol J. (1987). Incisor resorption caused by maxillary cuspids: a radiographic study. Angle Orthod, 57: 332-346.
34. Ericson S, Kurol J. (1986). Longitudinal study and analysis of clinical supervision of maxillary canine eruption. Commun. Dent. Oral. Epidemiol, 14: 172-176.
35. Ericson S, Kurol J. (1986). Radiographic assessment of maxillary canine eruption in children with clinical signs of eruption disturbances. Eur. J. Orthod, 8: 133-140.
36. Ericson S, Kurol J. (1987). Radiographic examination of ectopically erupting maxillary canines. Am. J. Orthod. Dentofacial Orthop, 91: 483-492.
37. Ericson S, Kurol J. (2000). Resorption of incisors after ectopic eruption of maxillary canines. A CT study. Angle Orthod, 70: 415-423.
38. Ericson S, Kurol J. (1988). Resorption of maxillary lateral incisors caused by ectopic eruption of the canines. An analysis of predisposing factors. Am. J. Orthod. Dentofacial Orthop, 94: 503-513.
39. Ericson S, Kurol J. (1987). Resorption of permanent incisors due to eruption of maxillary canines. A radiographic study. Angle Orthod, 57: 332-346.
40. Fastlicht S. (1954). Treatment of impacted canines. Am. J. Orthod, 40: 891-905.
41. Ferguson JW. (1990). Management of the unerupted maxillary canine. Br. Dent. J, 169: 11-17.
42. Fink DF, Smith RJ. (1992). The duration of orthodontic treatment. Am. J. Orthod. Dentofac. Orthop, 102: 45-51.
43. Fournier A, Turcotte JY, Bernard C. (1982). Orthodontic considerations in the treatment of maxillary impacted canines. Am. J. Orthod, 81: 236-239.

44. Gianelly A. (1993). The use of magnets in orthodontic therapy: panel discussion. Eur. J. Orthod, 15: 421-424.

45. Hansson C, Rindler A. (1998). Periodontal conditions following surgical and orthodontic treatment of palatally impacted maxillary canines-a follow-up study. Angle Orthod, 68: 167-172.

46. Heaney TG, Atherton JD. (1976). Periodontal problems associated with the surgical exposure of unerupted teeth. Br. J. Orthod, 3: 79-84.

47. Hunt NP. (1977). Direct traction applied to unerupted teeth using the acid-etch technique. Br. J. Orthod, 4: 211-212.

48. Ingervall B. (1993). The use of magnets in orthodontic therapy: panel discussion. Eur. J. Orthod, 15: 421-424.

49. Jacobs SG. (1994). Palatally impacted canines: aetiology of impaction and the scope for interception. Report of cases outside the guidelines for interception. Aus. Dent. J, 39: 206-211.

50. Jacobs SG. (1992). Reducing the incidence of palatally impacted maxillary canines by extraction of deciduous canines: a useful preventive/interceptive orthodontic procedure. Case reports. Aus. Dent. J, 37: 6-11.

51. Jacoby H. (1979). The 'ballista spring' system for impacted teeth. Am. J. Orthod, 75: 143-151.

52. Jacoby H. (1983). The etiology of maxillary canine impactions. Am. J. Orthod, 84: 125-132.

53. Johnston WD. (1969). Treatment of palatally impacted teeth. Am. J. Orthod, 56: 589-596.

54. Kettle MA. (1958). Treatment of the unerupted maxillary canine. Dent. Pract. Dent. Rec, 8: 245-255.

55. Kohavi D, Becker A, Zilberman Y. (1984). Factors in periodontal breakdown of treated palatally impacted canines. Am. J. Orthod. Dentofac. Orthop, 85: 72-77.

56. Kohavi D, Becker A, Zilberman Y. (1984). Surgical exposure, orthodontic movement, and final tooth position as factors in periodontal breakdown of treated palatally impacted canines. Am. J. Orthod, 85:72-77.

57. Kohavi D, Zilberman Y, Becker A. (1984). Periodontal status following the alignment of buccally ectopic maxillary canine teeth. Am. J. Orthod, 85: 78-82.

58. Kokich VG, Mathews DP. (1993). Surgical and orthodontic management of impacted teeth. Dent. Clin. N. Am, 37: 181-214.

59. Kokich VG. (2004). Surgical and Orthodontic Management of Impacted Maxillary Canines. Am. J. Orthod. Dentofac. Orthop, 126: 278-283.

60. Krogman WM. (1968). Biological timing and the dentofacial complex. J. Dent. Child, 35: 175-185.

61. Kuftinec MM, Shapira Y. (1995). The impacted maxillary canine: I. Review of concepts. J. Dent. Child, 62: 317-324.

62. Lappin MM. (1951). Practical management of the impacted maxillary canine. Am. J. Orthod, 37: 769-778.

63. Lew K. (1989). Alignment of buccaly displaced canines following premolar extractions: archwire or natural alignment. Aus. J. Orthod, 11: 85-88.

64. Lewis PD. (1971). Preorthodontic surgery in the treatment of impacted canines. Am. J. Orthod, 60: 383-397.

65. Loe H, Silness J. (1963). Periodontal disease in pregnancy. I. Prevalence and severity. Acta. Odontol. Scand, 21: 533-551.

66. Lu TC, Wang WN, Tarng TH, Chen JW. (1993). Force decay of elastomeric chains-a serial study. Part 2. Am. J. Orthod. Dentofac. Orthop, 104: 373-377.

67. Magnusson H. (1990). Saving impacted teeth. J. Clin. Orthod, 24: 246-249.

68. Massler M, Frankel JM. (1951). Prevalence of malocclusion in children aged 14-18 yrs. Am. J. Orthod, 37: 751-760.

69. McDonald F, Yap WL. (1986). The surgical exposure and application of direct traction of unerupted teeth. Am. J. Orthod, 89: 331-340.

70. McSherry PF. (1996). The assessment of and treatment options for the buried maxillary canine. Dental Update, 23: 7-10.

71. McSherry PF. (1998). The ectopic canine: A Review. Br. J. Orthod, 25: 209-216.

72. Mead SV. (1960). Incidence of impacted teeth. Int. J. Orthod, 16: 885-890.

73. Melkos Aristides B, Papadopoulos Moschos A. (2004). Periodontal aspects associated with the surgical and orthodontic treatment of impacted canines. Hell. Orthod. Rev, 7: 9-24.

74. Meyers CE. (1985). Extrusion of palatally impacted cuspids. J. Clin. Orthod, 19: 664-665.

75. Mitchell L, Bennett TG. (1992). Supernumerary teeth causing delayed eruption–a retrospective study. Br. J. Orthod, 19: 41-46.

76. Moyers RE. (1963). Handbook of Orthodontics. Year Book Medical Publishers Inc, Chicago.

77. Ngan PW, Wolf T, Kassoy G. (1987). Early diagnosis and prevention of impaction of the maxillary canine. J. Dent. Child, 54: 335-338.

78. Nielsen LI, Prydso U, Winkler T. (1975). Direct bonding on impacted teeth. Am. J. Orthod, 68: 666-670.

79. Orton HS, Garvey MT, Pearson MH. (1995). Extrusion of the ectopic maxillary canine using a lower removable appliance. Am. J. Orthod. Dentofac. Orthop, 107: 349-359.

80. Pearson MH, Robinson SN, Reed R, Birnie DJ, Zaki GA. (1997). Management of palatally impacted canines: the findings of a collaborative study. Eur. J. Orthod, 19: 511-515.

81. Power SM, Short MBE. (1993). An investigation into the response of palatally displaced canines to the removal of deciduous canines and an assessment of factors contributing to favourable eruption. Br. J. Orthod, 20: 215-23.

82. Rygh P. (1993). The use of magnets in orthodontic therapy: panel discussion. Eur. J. Orthod, 15: 421-424.

83. Sandler JP. (1991). An attractive solution to unerupted teeth. Am. J. Orthod, 100: 489-493.

84. Sandler PJ, Meghji S, Murray AM. (1989). Magnets and orthodontics. Br. J. Orthod, 16: 243-249.

85. Schindel RH, Duffy SL. (2007). Maxillary transverse discrepancies and potentially impacted maxillary canines in mixed-dentition patients. Angle Orthod, 77: 430-435.

86. Schour I, Massler M. (1941). The development of the human dentition. J. Am. Dent. Assoc, 28: 1153-1160.

87. Shah RM, Boyd MA, Vakil TF. (1978). Studies of permanent tooth anomalies in 7886 Canadian individuals. II. Congenitally missing supernumerary and peg teeth. J. Canad. Dent. Assoc, 6: 265-268.

88. Shapira Y, Kuftinec M. (1981). Treatment of impacted cuspids: the hazard lasso.

Angle Orthod, 51: 203-207.

89. Shiloah J, Kopezyk RA. (1978). Mucogingival considerations in surgical exposure of maxillary impacted canines: report of a case. J. Dent. Child, 45: 79-81.

90. Silness J, Loe H. (1964). Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. Acta. Odontol. Scand, 22: 121-135.

91. Sly WJ. (1950). Unerupted or impacted maxillary cuspid: report of a case. Am. J. Orthod, 36: 913-916.

92. Stangl DP. (1976). Conservative treatment of palatally impacted canines. Am. J. Orthod, 69: 328-334.

93. Storie DJ, Regennitter F, Von Fraunhofer JA. (1994). Characteristics of a fluoride-releasing elastomeric chain. Angle Orthod, 64: 199-210.

94. Strock MS. (1938). A new approach to the unerupted tooth by surgery and orthodontics. Am. J. Orthod, 24: 626-634.

95. Tegsjö U, Valerius-Olsson H, Anderson L. (1984). Periodontal conditions following surgical exposure of unerupted maxillary canines-a long term follow-up study of two surgical techniques. Swed. Dent. J, 8: 257-263.

96. Theilade J. (1960). An evaluation of the reliability of radiographs in the measurement of bone loss in periodontal disease. J. Periodontol, 31: 143-153.

97. Theofanatos GD, Zavras AI, Turner IM. (1994). Periodontal considerations in the treatment of maxillary impacted cuspids. J. Clin. Ped. Dent, 18: 245-252.

98. Usiskin LA. (1991). Management of the palatal ectopic and unerupted maxillary canine. Br. J. Orthod, 18: 339-346.

99. Usiskin LA. (1991). Management of the palatal ectopic and unerupted maxillary canine. Br. J. Orthod, 18: 339-346.

100. Vanarsdall R, Corn H. (1977). Soft-tissue management of labially positioned unerupted teeth. Am. J. Orthod, 72: 53-64.

101. Vardimon AD, Graber TM, Drescher T, Bourauel C. (1991). Rare earth magnets and impaction. Am. J. Orthod. Dentofac. Orthop, 100: 494-512.

102. Vardimon AD. (1993). The use of magnets in orthodontic therapy: panel discussion. Eur. J. Orthod, 15: 421-424.

103. Vermette ME, Kokich VG, Kennedy DB. (1995). Uncovering labially impacted teeth: apically positioned flap and closed-eruption techniques. Angle Orthod, 65:

23-34.

104. Von der Heydt K. (1975). The surgical uncovering and orthodontic positioning of unerupted maxillary canines. Am. J. Orthod, 68: 256-276.

105. Wennström JL. (1996). Mucogingival Considerations in Orthodontic Treatment. Seminars in Orthodontics, 2: 46-54.

106. Williams BH. (1981). Diagnosis and prevention of maxillary canine impaction. Angle Orthod, 51: 30-40.

107. Wisth PJ, Norderval K, Boe OE. (1976). Comparison of two surgical methods in combined surgical-orthodontic correction of impacted maxillary canines. Acta . Odontol. Scand, 34: 52-57.

108. Wisth PJ, Norderval K, Boe OE. (1976). Periodontal status of orthodontically treated impacted maxillary canines. Angle Orthod, 46: 69-76.

109. Woloshyn H, Artun J, Kennedy DB, Joondeph DR. (1994). Pulpal and periodontal reactions to orthodontic alignment of palatally impacted canines. Angle Orthod, 64: 257-264.

110. Zachrisson BU, Alnaes L. (1974). Periodontal condition in orthodontically treated and untreated individuals. II. Alveolar bone loss: Radiographic findings. Angle Orthod, 44: 48-55.

111. Ziegler TF. (1977). A modified technique for ligating impacted canines. Am. J. Orthod, 72: 665-670.

10. BIOGRAPHY

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