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Review Article

The Ectopic Maxillary Canine: A Review

PATRICK F. MCSHERRY B.A., B.DENT.SC., M.SC. (LOND.UNIV), F.D.S.ORTH(R.C.S.ED.),M.ORTH. (R.C.S.ED), M.DENT.SC. (UNIV. DUB.), F.F.D. (R.C.S.I.)

Department of Orthodontics, School of Dentistry, Royal Group of Hospitals and Dental Hospital, Grosvenor Road, Belfast BT12 6BP, UK

Abstract. *This article reviews the aetiology and management of the ectopic maxillary canine. Much controversy surrounds the causes of canine palatal ectopia. The recent evidence surrounding the genetic and guidance theories are examined. The management options are detailed and the indications for each treatment modality based on the available scientific evidence are presented. Finally, the untoward sequelae of canine ectopia are discussed.*

Index words: Ectopic Canine, Review.

Introduction

Orthodontics is considered to be a complex problem-solving domain (Hultgren *et al.*, 1994). A good example of this is the large number of patient factors and treatment variables which must be considered when dealing with maxillary canine ectopia. The complexity of this clinical problem is further compounded by the scarcity of properly controlled clinical research. The purpose of this paper is to review the various treatment options against the available scientific evidence.

Incidence/Epidemiology

The maxillary canine is second only to the mandibular third molar in its frequency of impaction. The frequency varies from less than 0·8 to 2·8 per cent (Shah *et al.*, 1978; Grover and Lorton, 1985). The condition is more than twice as common in girls (1·2 per cent) than in boys (0·5 per cent; Dachi and Howell, 1961). Canine impaction is found palatal to a the arch in 85 per cent of cases and labial/buccal in 15 per cent (Hitchin, 1956; Rayne, 1969; Ericson and Kurol, 1987b). There is some evidence that patients with Class II division 2 malocclusions and tooth aplasia may be at higher risk to the development of an ectopic canine (Kettle, 1957; Harzer *et al.*, 1994; Mossey *et al.*, 1994; Brenchley and Oliver, 1997).

Normal Development and Eruption Pattern

Broadbent (1941) stated that calcification of the permanent maxillary canine crown starts at 1 year old, between the roots of the first primary molar, and is complete at 5–6 years. By the age of 12 months the crown of the tooth is found between the roots of the first primary molar. At 3–4 years of age the canine passes over the line of the primary incisors to lie on the labial side of the root of the lateral incisor (Miller, 1963). At age 4 years the primary first molar, the first premolar germ and the canine lie in vertical row. Subsequent growth on the facial surface of the maxilla provides space for the forward movement of the canine so that its cusp comes to lie medial to the root of the deciduous canine. Moss (1972) states that the canine remains high in the maxilla just above the root of the lateral incisor until the crown is calcified. It then erupts along the distal aspect of the lateral incisor resulting in closure of the physiological diastema if present and the correction of the so called 'Ugly Duckling' dentition (Kurol *et al.*, 1997).

In a recent paper, Coulter and Richardson (1997) quantified the movements of the maxillary canine in three dimensions using lateral and posteroanterior cephalometric radiographs from the Belfast Growth Study taken annually between 5 and 15 years of age. It was shown that the canine travels almost 22 mm during that time. In the lateral plane the canines showed a significant movement in a buccal direction between 10 and 12 years of age. Before this age the movement was in a palatal direction. About three-quarters of the root is formed before eruption and root formation is complete 2 years after eruption. Hurme (1949) stated that gingival emergence of the maxillary canine after 12·3 years in girls and 13·1 years for boys was late. Thilander and Jacobsson (1968) regarded 13·9 years for girls and 14·6 years as very late for boys as by this time 95 per cent should have erupted. The maxillary canine is the last tooth to erupt in the upper arch with a deciduous predecessor and, therefore, is most susceptible to environmental influences such as crowding.

Aetiology of the Ectopic Canine

The aetiology of the ectopic canine is obscure, but probably multifactorial. The maxillary canine has the longest path of eruption in the permanent dentition and this may be a factor in the aetiology (Coulter and Richardson, 1997). Arch length discrepancy (crowding and spacing) is implicated in the aetiology of the ectopic canine. A space deficiency may result in the tooth erupting buccally or its impaction (Jacoby, 1983). Thilander and Jacobsson (1968) stated that crowding may be a factor in labial impaction, but not in palatal impaction. Jacoby (1983) found that in 85 per cent of cases where the canine erupted palatally in his study that adequate space was present in the arch. He

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suggested that a possible explanation for canine impaction to be excessive space in the canine area. Other suggested causes of palatal impaction are trauma to the maxillary anterior region at an early stage of development (Brin *et al.*, 1993).

Studies have shown that there is a higher incidence of palatally ectopic canines in cases with peg shaped small lateral incisors or in cases with missing lateral incisors (Becker *et al.*, 1984). The ' Guidance Theory' in its simplest form regards the distal aspect of the lateral incisor root as the guide to allow the canine to erupt safely into position. If the lateral incisor is anomalous or missing this guidance is missing resulting in palatal displacement of the canine. Becker *et al.* (1981) found a 5·5 per cent rate of congenital absence of lateral incisors in a large group of patients with palatal canines. This was 2·4 times the rate in the general population. It was hypothesized that the lateral incisor was not sufficiently developed at the time when its root would be most important for guidance of the canine. Oliver *et al.* (1989) found that lateral incisors on the side of canine impaction were generally smaller than on the non impacted side in a sample of 31 Causacian subjects. Other studies could demonstrate no or a weak association between anomalous lateral incisors and canine impaction (Mossey *et al.*, 1994; Brenchley and Oliver, 1997).

Delayed exfoliation of the primary canine may result in continued palatal movement of the permanent successor. However, Thilander and Jacobsson (1968) considered this persistence of a primary canine to be a consequence rather than a cause of impaction. Other possible causes include pathological lesions, ankylosis, odontomes, or supernumerary teeth. There may also be a higher incidence of impaction of the maxillary canine following alveolar bone grafting in patients with cleft lip and palate (Semb and Schartz, 1997).

A genetic or familial trend has been pointed out by some workers. Zilbermann *et al.* (1990) found that the relatives of patients with palatal canines are likely to exhibit palatally displaced canines, anomalous lateral incisors and late developing dentitions. Bjerklin *et al.* (1992) found that ectopic eruption of maxillary canines occurs in a higher frequency than normal in children with other eruption disturbances such as ectopic first permanent molars and concluded that the aetiology was presumably hereditary. A genetic basis has been suggested by Peck *et al.* (1994). They reviewed the evidence regarding the palatally displaced canine as a dental anomaly of genetic origin concluding that palatally displaced canines appear to be a product of polygenic, multifactorial inheritance. Pirinen *et al.* (1996) concluded from their study on 106 consecutive patients with displaced canines having examined the 1st degree relatives and the 2nd degree relatives that palatal displacement of the canine is both genetic and related to genetic incisor-premolar hypodontia and peg-shaped lateral incisors. Hypodontia was noted in 19–20 per cent of 1st /2nd degree relatives and this was 2·5 times the population prevalence. The prevalence of palatally displaced canines was 4·9 per cent (also 2·5 times the population prevalence). McSherry and Richardson (in press) quantified the movements of the 20 ectopic palatal maxillary canines in three dimensions using lateral and posteroanterior cephalometric radiographs from the Belfast Growth Study taken annually between 5 and 15 years of age. In comparison to the normal eruption, the ectopic canine always travelled in a palatal direction and failed to demonstrate the late buccal movement which normally occurs at age 10–12 years.

Treatment Planning Considerations

The ectopic maxillary canine can often require complex multidisciplinary treatment involving oral surgical, restorative, periodontic, as well as orthodontic components (Bishara, 1994).

Management Options

The patient with an impacted maxillary canine initially must undergo a comprehensive assessment of the malocclusion to localize the canine and decide on its prognosis for alignment. Factors affecting the prognosis include patient co-operation, age, general oral health, skeletal variation, and presence of spacing or crowding in the arch (McSherry, 1996). Other conditions to be taken into account are the position of the canine in the three planes of space and whether any resorption of the incisor roots has taken place. It is important that the specialist be vigilant with respect to the malposition of the maxillary canine especially during its development and be conversant with the normal eruption pattern. Interceptive measures, when appropriate, are most advantageous in terms of cost benefit than other more invasive procedures. Patient and parent counselling on the treatment options and informed consent is essential to avoid any medicolegal problems (Machen, 1989).

The treatment alternatives include:

- Interceptive treatment.
- Surgical exposure and orthodontic alignment.
- Other options.

Interceptive Treatment by Extraction of the Deciduous Canine

Ericson and Kurol (1988a) carried out an extensive prospective longitudinal study on a preselected group of 10–13 year old children (mean age 11·4 years) with palatally ectopic canines and uncrowded arches. They found that 78 per cent of the canines reverted to a normal path of eruption following extraction of the primary canine. The percentage improvement depended on the degree of overlap of the canine over the lateral incisor root and varied between 64 and 91 per cent. An improvement was seen in 50 per cent of the successful cases after 6 months. If no improvement was seen after 12 months then none could be expected. No control group was used in this study as the authors considered it to be unethical and the presence or absence of the lateral incisor was not specifically mentioned. Power and Short (1993) assessed the effect of removal of primary canines on the subsequent eruption of the successor. They found that the success rate was lower at 62 per cent, but a further 19 per cent showed some improvement. The results showed that the presence of crowding inhibits eruption of the permanent canine. The horizontal overlap of the canine over the nearest incisor was found to be the most significant factor. If this exceeded

half the tooth width then success was unlikely. Both studies would seem to suggest that if the patient was over 13 years of age that alternative treatment options should be considered.

Based on the results of these studies it would seem appropriate to recommend the extraction of the primary canine as an interceptive measure when:

- The patient is aged 10–13 years.
- The maxillary canine is not palpable in its normal position and radiographic examination confirms palatal canine ectopia. Removal of the primary canine may show less favourable results where the permanent canine is located in a more medial position or when the patient older than the ideal age group (Kurol *et al.*, 1997).
- If there is no improvement in canine position within 12 months on the OPG, alternative treatment is indicated. Clinical re-evaluation and follow-up radiographs should normally be taken at 6-month intervals (Ericson and Kurol, 1988a).

The elimination of dental crowding in the arch particularly in the canine/premolar area can possibly stimulate eruption into the arch (Kurol *et al.*, 1997). However Kuftinec *et al.* (1995) recommend that irreversible decisions such as the extraction of permanent teeth to allow canine eruption should be delayed for as long as possible.

Localization of the Maxillary Canine

Localization of the unerupted canine involves inspection, palpation, and radiographic assessment. The position of the crown of the lateral incisor can give a clue as to the position of the crown of the unerupted canine, for example, if the canine is lying on the labial aspect of the lateral root the crown may be proclined (Moss, 1972; Bishara *et al.*, 1976). Often the crown of the unerupted canine can be palpated either in a buccal position or in a palatal position. Clinicians should become suspicious of the possibility of canine ectopia if the canine is not palpable in the buccal sulcus by the age of 10–11 years or if palpation indicates an asymmetrical eruption pattern. Inspection and palpation in the canine region is recommended annually from age 8 years (Ericson and Kurol, 1986 a,b).

It has been suggested that radiographic procedures prior to the age of 10 years are of little benefit. Radiographs are indicated before 11 years of age if there is an asymmetric path of eruption as determined by palpation, if the lateral incisor is late in erupting or is tipped labially, if the lateral incisor is missing or there is a family history of ectopic canines. After age 11, radiographs are indicated in all individuals with unerupted and non-palpable canines (Kurol *et al.*, 1997). Conventional radiography usually involves taking a combination of radiographs (peri-apicals, standard upper anterior occlusal, orthopantomogram) and the use of the principle of vertical or horizontal parallax. The use of an orthopantomogram or lateral cephalogram can also assist in determining the vertical position of the canine. The use of these radiographs will help to localize the canine in relation to the dental arch and determine the angulation, height, and mesiodistal position of the canine (Southall and Gravely, 1989; Fox *et al.*, 1995). The use of computerized tomography (CT) to localize canines has been described (Ericson and Kurol, 1988b; Schmuth *et al.*, 1992). It is useful to predict the exact position of the canine, the degree of crowding, incisor resorption, and the width of the dental follicle. However, this method is rarely used because of the high cost of equipment. A new development is the use of magnetic resonance imaging (MRI) and scanora-tomography in the localization of the canine (Kurol *et al.*, 1997).

Exposure With or Without Orthodontic Traction

The conventional treatment option for impacted canines is exposure and orthodontic alignment. The prognosis for alignment is dependent on a number of factors which include the age of the patient, spacing/crowding and the vertical, anteroposterior, and transverse position of the canine crown and root. If the inclination of the canine in relation to the midline is greater than 45 degrees then the prognosis for alignment worsens. The closer the tooth is to the midline the poorer the prognosis. For successful alignment, the tooth should not be ankylosed and the root not be dilacerated (Kurol *et al.*, 1997). The further the canine needs to be moved then the poorer the prognosis for a successful outcome. To provide for a stable result it is essential to obtain a good buccal overlap and correct root positioning (Zachrisson and Thilander, 1985).

The outcome of surgical exposure and orthodontic alignment will depend on a number of factors. As with all orthodontic treatment co-operation and motivation of the patient is paramount, and the general dental health should be excellent since the treatment time in these cases is often prolonged. It is generally agreed that the optimal time for alignment is during adolescence (Altonen and Myllarniemi, 1976; Galloway and Stirrups, 1989).

Palatal Ectopic Canines

Essentially, there are three methods for exposure and alignment of the canine (McSherry, 1996).

- Open surgical exposure and spontaneous eruption.
- Open surgical exposure and packing with subsequent bonding of an auxiliary.
- Closed surgical exposure and bonding of attachment intra-operatively.

The first method is probably most useful when the canine has the correct inclination and will then erupt spontaneously. The second option is the exposure of the crown of the canine with packing. The pack is removed about a week postoperatively and an attachment bonded with subsequent traction using a fixed appliance. There is some evidence that the periodontal status may be compromized (Kohavi *et al.*, 1984; Becker *et al.*, 1996). This evidence is not convincing and a randomized controlled clinical trial is ongoing (Burden, personal communication).

The third option is the closed technique. This involves the reflection of a palatal mucoperiosteal flap. An attachment is bonded to the crown of the tooth and an eyelet wire or gold chain exits through the flap to gain attachment to the fixed appliance for immediate traction. The ability to gain attachment permits a more conservative approach to

the exposure (Becker *et al.*, 1996). However, a disadvantage of this technique is that if bond failure occurs then re-exposure is necessary. Becker *et al.* (1996) suggests the use of an eyelet bonded in a mid-buccal position on the crown of the impacted tooth at surgery as these have the highest success rate.

Biomechanical Considerations

Light forces of the magnitude of 20–60 g should be applied to align the canine (Bishara, 1994; Kuftinec *et al.*, 1995). Various methods have been described for aligning the canine and these are described in detail by Hunter (1983), and Kokich and Matthews (1993). These usually include the use of fixed appliances with a transpalatal bar and/or headgear to control vertical anchorage. The provision and maintenance of adequate space in the canine area is essential. Application of force can be in the form of elastic or wire traction. Usiskin (1991) described the use of gold chain bonded to the crown of an unerupted canine to apply traction to align the tooth. A palatal arch with soldered hooks attached to apply traction to pull the canine away from the lateral incisor is described. The use of the Ballista spring (a wire loop constructed of 0·012-inch stainless steel wire) has been described by Jacoby (1979). Roberts-Harry and Harradine (1995) described the use of a sectional approach to maxillary canines using a transpalatal arch for anchorage. They use a 0·017- by 0·025-inch TMA sectional archwire from the first molar to canine providing a low force over a long range, which is controllable and remains stable in the 0·022-inch slot. Bennett and McLaughlin (1997) describe the use of a wound on auxiliary to achieve first vertical movement and then lateral movement. It is constructed of 0·014-inch steel wound on to 0·019- by 0·025-inch stainless steel. Orton *et al.* (1995) describe the use of a lower removable appliance with soldered hooks on the cribs. Elastic traction is applied to the canine which has a gold chain with a hook bonded to the tooth. The vector of force used to align the canine can be changed to first move the canine away from the incisor roots and then vertically and buccally. Fixed appliances are used to finish the alignment and create adequate buccal root torque and overlap. Magnetic forces have been advocated by some authors to apply force to the ectopic canine for alignment (Sandler *et al.*, 1989; Darendelilier and Friedli,1994).

Retention Considerations

Becker *et al.* (1983) evaluated post-treatment alignment in cases whose treatment was completed. They found spacing and rotations in 17·8 per cent of impacted canines and only in 8·7 per cent on the control side. Woloshyn *et al.* (1994) found in a sample of previously exposed palatally impacted canines approximately 40 per cent displayed noticeable relapse and were judged to be intruded, lingually displaced, mesially rotated an average of 3 years and 7 months post-treatment. The contralateral untreated side were found to be 91 per cent normal in appearance. They also found pulpal obliteration in 21 per cent of impacted canines and discoloration in 75 per cent of cases post-treatment. Bennett and McLaughlin (1997) suggest the following to prevent relapse:

- Full correction of torque.
- Early correction of rotations.
- Circumferential supracrestal fiberotomy.
- Provision of a bonded retainer.

It would seem appropriate to recommend surgical exposure and orthodontic alignment when:

- The patient is willing to wear orthodontic appliances.
- The patient is well motivated and has good general dental health.
- Interceptive measures are inappropriate (Ericson and Kurol, 1988a).
- The degree of malposition is not too great to preclude orthodontic alignment. The long axis of the ectopic canine should not be too horizontal or too oblique. The closer the crown is to the midline and the root is to the mid-palatal suture the poorer the prognosis for alignment (Kurol *et al.*, 1997)
- Any evidence of tooth resorption or other pathology should be such that it is more desirable to preserve the canine. For example, where a resorbed lateral incisor has a very poor prognosis, it may be advantageous to attempt alignment of a poorly placed canine to replace the lateral incisor.

Buccally Ectopic Canines

Buccal/labial impaction is much less frequent than palatal impaction occurring in only 15 per cent of cases (Jacoby, 1983). When a buccally ectopic canine is exposed it is essential that a closed technique or an apically repositioned flap be used to preserve the attached gingivae (Vanarsdall and Corn, 1977; Wong Lee and Wong, 1985). Vermette *et al.* (1995) examined the use of the apically repositioned flap versus the closed technique, and found that the apically repositioned flap resulted in more unaesthetic sequelae than the closed technique in maxillary anterior teeth.

No Active Treatment/Leave and Observe

In some cases it may be preferable to carry out no active treatment except that of regular radiographic monitoring. The most frequent complication appears to be follicular cystic degeneration, although the frequency of this is unknown. Other odontogenic tumours may arise very rarely. There may be localized loss of attachment and marginal breakdown of the adjacent teeth, which may necessitate the removal of the canine and the affected teeth. There is a need to regularly monitor the unerupted canine with respect to cystic degeneration, root resorption, and the other possible complications. It is not known what the optimal time interval between radiographs should be to reduce the radiation dosage for the patient and detect any lesions which may be arising.

No active treatment could be recommended if:

- The patient does not want treatment.
- There is no evidence of resorption of adjacent teeth or other pathology.
- Ideally, there is a good contact between the lateral incisor and 1st premolar or good aesthetics/prognosis for the deciduous canine.

- There is a severely displaced canine with no evidence of pathology, particularly if it is remote from the dentition, provided it is monitored radiographically.

Surgical Removal of Permanent Canine

Surgical removal of the tooth is indicated if there is poor patient co-operation or poor position for alignment (canine in an oblique or horizontal position). Ideally, there should be a good lateral incisor/first premolar contact. In cases where the patient is willing to undergo comprehensive treatment, it is possible to use the first premolar as a adequate replacement for the canine by mesiopalatal rotation and the introduction of buccal root torque. Grinding of the premolar palatal cusp is also necessary. Other factors to consider include tooth size discrepancy, and the difficulties in handling unilateral mechanics (Bishara, 1994). In a case where the primary canine is left following extraction of the permanent successor it is not possible to tell how long the primary canine will remain intact. Little longitudinal research has been carried out on this aspect of canine ectopia. In the event of the primary canine becoming unsightly or being lost it could be extracted and replaced by a prosthodontic restoration whether fixed, removable, or osseointegrated implant. Orthodontic treatment may be required to open space prior to restoration.

The surgical removal of ectopic canines is recommended when:

- Patient declines active treatment and/or is happy with appearance.
- There is evidence of early resorption of adjacent teeth.
- The patient is too old for interception.
- There is a good contact between the lateral incisor and 1st premolar or the patient is willing to undergo orthodontic treatment to substitute the first premolar for the canine.
- The degree of malposition is too great for surgical repositioning/transplantation.

Surgical Repositioning/Alignment or Transplantation

The prognosis for autotransplantation of ectopic canines in adults is poor (Moss, 1974). Periodontal ligament healing without any root resorption varied between authors from 25 per cent to 85 per cent. At a later stage of development the root is fully formed and the chances of pulpal and periodontal healing is reduced (Andreasen 1987; Schatz *et al.*, 1992). The optimal developmental stage for autotransplantation is when the root is 50–75 per cent formed (Kristerson, 1985). In light of the good prognosis for autotransplantation of premolars documented by Andreasen (1992) canine transplantation should be planned as early as possible. The technique is described in detail by Andreasen (1992). In a recent paper by Berglund *et al.* (1996) a method of exposure and partial alignment was described for canines in oblique horizontal positions. Atraumatic removal of these teeth may be difficult. The canine is pretreated with distal and vertical traction following exposure in order to facilitate atraumatic removal and autotransplantation. Of the 21 autotransplantations, 20 have been successful.

Autotransplantation could be recommended when:

- Interceptive measures are inappropriate or have failed.
- The degree of malposition is too great to make orthodontic alignment feasible.
- Adequate space is available for the canine.
- The prognosis is good for the tooth to be transplanted and it can be removed atraumatically.
- There is no evidence of ankylosis of the canine.

Sequelae of Canine Ectopia

Internal or external root resorption of teeth adjacent to the ectopic canine is the most common sequela. It has been estimated that 0·7 per cent of children in the 10–13-year-old age group have permanent incisors resorbed, as a result of canine ectopia. Root resorption can be expected in about 12·5 per cent of the incisors adjacent to ectopic maxillary canines (Ericson and Kurol, 1987a, b). Resorption of the lateral incisor is more common than the central incisor. Rarely the first premolar is resorbed (Postletwaite, 1989). A number of studies have found that females are more likely to be affected (Sasakura *et al.*, 1984; Rimes *et al.*, 1997). If the canine has migrated to a position medial to the mid-root of the lateral incisor, the resorption is more likely. In addition, if the angulation of the long axis of the canine to the midline on an orthopantomogram exceeds 25 degrees the risk increases by 50 per cent (Ericson and Kurol, 1988c). Lateral incisors are more commonly resorbed palatally and at the mid root level than at the cervical or apical regions (Ericson and Kurol, 1987b; Rimes *et al.*, 1997). There appears to be no association between enlarged follicles surrounding the canine and the potential for resorption. Cystic degeneration is uncommon and the prevalence is not known. However, Ericson and Kurol (1986a) found no evidence of cystic degeneration amongst 3000 school children. This is not surprising as it would be expected that cystic degeneration would increase in frequency in older age groups. However, even in older age groups the frequency is thought to be low (Mourshed, 1964; Brown *et al.*, 1982). Lastly, late resorption of the unerupted canine itself can occur (Kurol *et al.*, 1997). Loss of vitality of the incisors can occur and the poor aesthetics associated with the primary canine may be a concern for the patient. In some cases the canine may erupt at a late stage under a prosthesis. Surgical risks include damage to adjacent teeth, re-exposure may sometimes be required and the potential risks from general anaesthesia. Orthodontic treatment is not without risks which include root resorption decalcification, periodontal problems, canine ankylosis, and failure to complete treatment.

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