



Diagnosis and Orthodontic Management of Transposition: A Review

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Abstract

Dental transposition is a disturbance of the eruptive position of the tooth, which occurs when the adjacent teeth change position. Although its incidence is relatively rare, the specifics of managing transpositions require special knowledge of the classifications and a codified diagnostic approach. Many factors must be considered in selecting treatment options, such as patient compliance, esthetics, function, and age to decide whether treatment of a transposition should involve tooth extractions, alignment of the teeth in the order of the transposition, or orthodontic correction of the transposition. The aim of this article is to highlight, through a detailed literature review, the diagnostic and therapeutic approach of dental transpositions in orthodontic practice.

Subject Areas

Dentistry, Orthodontics

Keywords

Orthodontics, Transposition, Diagnosis, Management

1. Introduction

Tooth transposition is a disturbance of eruptive position, occurring when adjacent teeth switch position [1]. It has been defined as the positional interchange of two adjacent teeth, particularly of the roots, or the development or eruption of a tooth in a position occupied normally by a non-adjacent tooth [2].

It is a severe and rare form of ectopic eruption. Data's analysis of primary studies revealed that dental transposition has an average prevalence of 0.33% [3].

In a locally conducted study, the prevalence of tooth transposition was 2%. The female population was more affected (64%) and tooth transposition occurred

only in the maxillary arch. Of all the teeth, the canines were the most involved in this anomaly. Transposition was associated with tooth agenesis in 18% of cases, peg lateral incisors in 27%, and persistent deciduous teeth in 18% [4].

The diagnosis of dental transpositions is based on clinical observation and on the elements derived from complementary examinations. This diagnostic approach is crucial in the etiological and clinical diagnosis as well as in the evaluation of the pathological consequences of the transposition within a dysmorphism.

All these elements clarify the specificities of transpositions and the various challenges encountered by the orthodontist in the management of this anomaly.

2. Classification

Complete transposition and incomplete transposition are distinguished. A complete transposition is when the crowns and all root structures of the teeth involved are moved parallel to their transposition position.

In incomplete transposition (also called pseudo-transposition or partial transposition), the displacement is partial. In this case, either transposed crowns can be seen while the root apices remain in their normal position. Alternatively, the crowns may be unaffected, while the root apices are transposed [5].

2.1. PECK'S Classification

In 1995, PECK [6] categorized tooth transposition into five types, according to the affected teeth: first premolars transposed with canines, canines with lateral incisors, first molars with canines, lateral incisor with central incisor, and canine transposed with central incisor. The five types of transposition are detailed in **Table 1**.

Table 1. Peck's classification of transposition [6].

Maxilla	Type	Transposition	Description
	Mx.C.p1	Canine - first premolar	Canine in buccal ectopia, rotated mesiobuccally, wedged between premolars First premolar tilted distally and rotated mesiopalatally
	Mx.C.I2	Canine - lateral incisor	The temporary canine is also frequently found, persisting on the arch causing a lack of temporary space on the maxillary arch. Canine erupted mesially and buccally or completely mesially to the lateral incisor
	Mx.C. to M1	Canine - first molar	Canine occupying site of prematurely lost deciduous first molar
	Mx.I2.I1	Lateral incisor - central incisor	Complete positional interchange of lateral and central incisors
	Mx.C. to I1	Canine - central incisor	Canine developed in space left vacant by premature loss of central incisor This transposition is characterized by the loss (absence) of the permanent central incisor on the ipsilateral side, which allows the differential diagnosis with Mx.C.I2 in which the central incisor is present.
Mandible	Mn.I2.C	Canine - lateral incisor	Lateral incisor developing with severe distal tilt and rotation, erupting in site normally occupied by first premolar and canine

In his classification, PECK considers pseudo-transpositions to be variations in the dental sequence that would mimic a transposition.

This includes varying degrees of ectopic eruptions not having all the required characteristics to be classified as transpositions, and cases of supernumerary teeth, especially the supernumerary maxillary premolar.

2.2. ATTIA's Classification

It is a classification of canine transpositions for therapeutic purposes, divided into four clinical forms considering their etiologies in order to allow differential diagnoses between a primary transposition, a pseudo-transposition and secondary transposition [7].

3. Etiology

The etiology of transposition is still unclear and not fully understood [8].

Suggestions describe a variety of theories to explain the phenomenon including: Heredity, variation in embryologic development, transposition of tooth buds at the anlage stage, early loss of primary teeth, migration of a tooth during eruption, trauma and prolonged retention of primary teeth [8] [9].

It is therefore possible to distinguish between primary etiologies, notably genetics and hereditary, and others secondary to local or locoregional conditions.

3.1. Primary Causes

3.1.1. The Congenital Hypothesis

During an early stage of odontogenesis, a congenital deviation of the dental buds would take place rendering the transposition a primitive and essential dystopia. This deviation is explained by the inversion of the sequence of the buds within the dental lamina which would initiate dental transposition [10].

Several theories are retained, the transposition would be due to an inter migratory change of the epithelial cords at the origin of the dental buds [11] [12].

SPERBER explains in his theory that the order (incisor, canine and then premolar) in the arch is determined by the genes of dental development, in accordance with the theory of genetic fields involved in the migration of germs [11] [12].

When these genetic fields are not functioning properly, dental transposition occurs. This theory would explain the familial cases of bilateral transpositions.

According to JOSHI and BHATT [13], transposition is due to a congenital deviation of dental buds at the beginning of their development.

3.1.2. Heredity

The hereditary origin of dental transpositions is frequently invoked. It is mainly based on the frequency of familial and bilateral forms [14].

Also, the frequent association of transpositions with other anomalies known to be traits under genetic control, such as dental agenesis and hypoplasia, reinforces the hypothesis of the hereditary etiology.

3.2. Secondary Causes

Several factors that secondarily influence tooth position during its evolution and eruption are incriminated in the etiopathogenesis of dental transpositions.

The main described are: deviation of the eruption trajectory, retention of temporary teeth, trauma, cystic process and tumors, dento-maxillary disharmony and infectious accidents [15].

4. Diagnosis

The diagnostic strategy includes the patient's history, clinical and radiological examinations. These elements provide the orthodontist with a set of presumptions that allow him to make a diagnosis of dental transposition with certainty.

4.1. The Medical Interview

The interview is a crucial step that enables the orthodontist to learn about the patient's age and growth potential, the gender, family predisposition to transpositions and patient's cooperation, which will later guide the choice of treatment.

It guides the identification of patient's medical and surgical history, the presence of a neonatal suffering ground and drug's intake.

In terms of local history, it reveals anterior traumas and the history of temporary tooth (infections, trauma, premature loss, etc.).

4.2. Clinical Examination

On clinical examination, various signs suggestive of transposition are noted notably an interchange between the position of 2 teeth, the persistence of the temporary canine, rotations and other associated anomalies (dental agenesis, peg teeth...).

Clinical presumptive elements to transpositions:

- An interchange between the position of 2 teeth.
- The presence of a canine in an ectopic position (vestibular, palatal).
- The absence of a canine, associated or not to a vestibular or palatal swelling.
- The persistence of the temporary canine with temporary crowding, mesiorotation of the first premolar and vestibular position of the canine in the cases of Mx.C.P1.
- The persistence of the canine with temporary crowding, a mesiovestibular position of the canine relative to the lateral itself in disto vestibular rotation in cases of Mx.C.I2.
- A canine in mesio-rotation with a palatal position at the level of the site of the first permanent first permanent molar which is absent in the cases of Mx C to M1.
- A persistent temporary canine with a canine in place of the central incisor which is absent in cases of Mx.C to I.

4.3. Radiological Examination

The radiological examination is an essential element to transposition's diagnosis,

its type and to give a prognosis on the treatment that can be performed.

It permits to check the dental formula and highlight associated discrepancies, distinguish between total and partial transposition, identify any other anomalies that may be present in transpositions (supernumerary teeth, agenesis, peg teeth), discern transposition from pseudo-transposition and determine the proximity of the incriminated teeth to the anatomical structures.

4.3.1. Panoramic Radiography

It is a first intention radiological examination, essential for the diagnosis of transpositions. It allows to:

- Objectify the transposition
- Perform the dental assessment
- Highlight agenesis and other anomalies
- Compare the right and left sides and to define if the transposition is uni or bi-lateral
- Specify the type of transposition: complete transposition, pseudotransposition.

4.3.2. Retroalveolar Radiographs

Retroalveolar radiographs using the standard plane-parallel method are used to evaluate the vertical and mesio-distal position of the transposed tooth.

It allows to define the stage of root construction of the tooth, as well as morphology and the presence or absence of abnormalities or pathological elements on the on the eruption path.

4.3.3. The Cone Beam Volume Tomography or Dentascan

Three dimensional imaging by using Cone beam volume tomography or Dentascan allows to:

- Evaluate the relationship between the teeth, roots and adjacent anatomical structures
- Specify the palatal or vestibular position of impacted teeth
- Objectify the transposition
- Evaluate root resorptions
- Establish a prognosis
- Choose an approach for impacted teeth.
- Search for pathological elements (cysts, tumors, supernumerary teeth)

5. Factors Influencing Treatment Choice

Management and treatment of canine transposition can be challenging for an orthodontist. The clinician must first decide whether to correct the transposition or maintain the teeth in their transposed positions [16].

Many factors must be considered for transposition treatment planning so that the benefits to the patient outweigh the harm. These factors include dental morphology; occlusal considerations; facial esthetics; stage of development and position of the root apices; the positions of the crowns and the roots in the dentoal-

veolar process in all 3 planes; treatment time and patient's motivation [17] [18] [19] [20].

The correction attempt should be made in adequate bucco-lingual thickness in the region and also in situations of great aesthetic damage by transposition [21].

The less the canine has descended into its position, the wider the dentoalveolar process will be; this provides the opportunity to move the teeth within the bone and decreases the risk of negative effects [22].

6. Treatment Options

Treatment in transposition cases may be divided into interceptive and definitive treatment.

When incipient transposition is detected early, interceptive treatment can be accomplished with minimal disturbance to the surrounding tissues. However, when detected at a later stage, the repositioning of teeth to their normal sequence in the arch is fairly complex [23]. Treatment options include alignment of teeth in their transposed positions, extraction of one or both transposed teeth, or orthodontic movement to their correct positions in the arch.

6.1. Interceptive Treatment

Early diagnosis of a developing transposition is based on thorough intraoral examination, followed by complete radiographic analysis, before reaching 10 years of age preferably between the ages of 6 and 8 years [5].

The orthodontic correction of complete transposition is complex. The key to success is to treat early, because treatment can be accomplished with fewer possibilities of injuring the surrounding tissue. Early identification of the problem before the permanent canines and first premolar erupt tends to optimize tooth movements in achieving acceptable alignment, while minimizing severe arch collapse and asymmetry [5].

6.1.1. Interception or Guidance

It is possible to intercept canine transposition when the diagnosis of transposition is made early, at the mixed dentition stage and when the permanent canine root is half formed. This may be possible when the etiology of the transposition is identified: cyst, odontoma, supernumerary teeth or dental crowding.

Therefore, interception can be achieved in two ways:

- If a supernumerary germ or a cyst is involved, the treatment will be the excision of the pathological element, space arrangement by temporary canine avulsion then realization of a conductive alveolectomy so that the canine having achieved half of its root edification can follow the path of least resistance and erupt in a normal position [15].
- In case of crowding, serial extractions associated with a conductive alveolectomy will be effective in order to intercept the transposition and reduce the crowding [24].

6.1.2. Placement in Normal Position during a Fixed Transposition

If transposition is diagnosed early in a child with a canine transposed in high position, there is a possibility of bringing it to its normal position even if it is in fixed transposition between the 2 premolars. Three conditions must be fulfilled [25]:

- The transposed canine is high enough in the maxilla; its cusp tip should be above the collar of the other transposed teeth.
- The space required for the placement of the canine has been maintained by the persistence of the temporary canine or by orthodontically prepared.
- The other tooth involved in the transposition is in a favorable position for the passage of the canine without interference.

Particular attention should be paid to the periodontium during this type of treatment. Mucogingival surgery will be often needed before treatment in order to restore a sufficient thickness of keratinized tissue and avoid dehiscence and recession or even promote bone reconstruction during the treatment.

According to Attia [25], a slight intrusion force on the transposed canine is first necessary so that the movement takes place in an area where the bone is denser and to reduce the risks for the periodontal structures associated with a mesio-distal force in order to carry out the movement of gression (either mesial for the Mx.C.P1, or distal for the Mx.C.I2)

In case of Mx.C.P1 transposition, attention should be paid to the vestibular root of the first premolar which can interfere with canine movement which can lead to resorption. PECK *et al.* [6] recommend using a lingual root torque instead of rotation in order to erase the vestibular root of the premolar.

In case of Mx.C.I2 transposition, it will be necessary to carry out a palatal displacement of the lateral incisor in order to allow passage of the canine mesially.

To perform the canine movement, ATTIA proposed a particular sectional device: The ATTIA trombone (Figure 1).

This trombone will achieve the slight mesial or distal intrusion force required depending on the transposition. The mesial or distal displacement of the canine

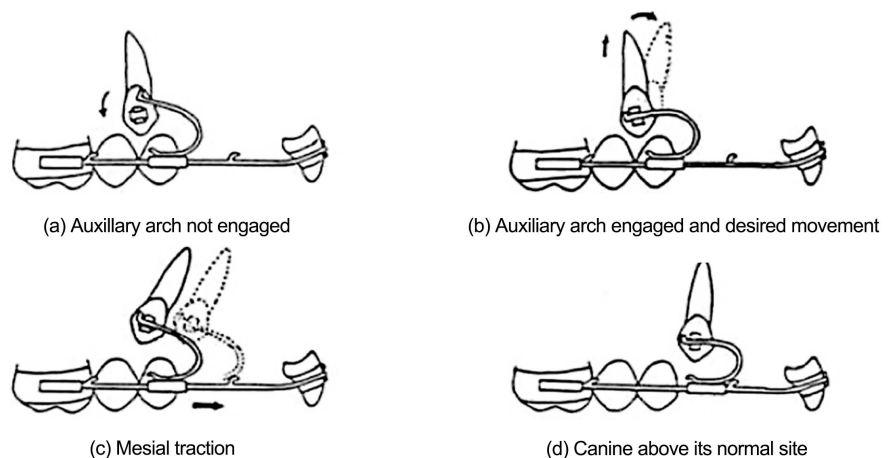


Figure 1. Principles of ATTIA trombone [25].

will be carried out using an elastomeric chain stretched between the trombone and the arc-welded hook. The canine will then be brought to the arch by engaging the wire in the canine bracket as for a classic alignment/leveling phase.

6.1.3. Placement in Normal Position of a Tooth in Pseudotransposition

This transposition, most often concerning the lateral incisor and the canine, is almost always treatable orthodontically because crowns are transposed while the roots are in their respective normal positions.

A rotational force will be applied to the transposed teeth then a classic alignment will be carried out in the space created by extraction of the persistent deciduous teeth [26].

6.2. Definitive Treatment

When deciding on the best treatment option the following factors should be considered: if the transposition is complete or incomplete, the overall malocclusion, any spacing or crowding present, and the patient preference [27].

When transposition is incomplete and the involved teeth have their root apices in their normal location, a relatively simple procedure is usually required to upright, rotate, and align their crowns to their usual position, provided sufficient space is available in the arch [26].

When transposition is complete, the repositioning of the teeth to their normal anatomic sequence in the arch is challenging and extremely complex. There is an increased risk of developing root resorption, bone loss, gingival recession and ankylosis.

Canines are essential both for function, providing canine guidance for occlusion, as well as for esthetics, giving the patient correct dental and gingival symmetry. If the case allows for correction of the transposition, the esthetic and functional results are improved [19].

Transposition of the maxillary canine and the lateral incisor should generally be corrected for esthetic reasons. However, when the maxillary canine and first premolar are involved, the transposed order can be maintained with no esthetic or functional problems, except for the palatal cusp of the premolar, which can produce interferences and should therefore be reduced. This treatment option usually takes less treatment time and avoids damaging the supporting tissues, root resorption, and loss of pulp vitality [28] [29].

In the mandible, it is consensual that the orthodontist should not try to correct the transposition, treating with extraction of the transposed tooth, usually the lateral incisor or aligning the teeth in their transposed order concomitant with reshaping of their incisal and/or occlusal surfaces [23] [28].

6.2.1. Alignment in Transposed Position

This treatment most often concerns the transposition Mx.C.P1. Normally, a pleasing appearance can be achieved by leaving the teeth in the transposed position with less than ideal function. Some enamel reduction of the bicuspid palatal

cuspid is normally needed. Buccal root torque of the bicuspid improves esthetics and reduces the need for enamel reduction [5]. An optimized group function is sought.

In cases of canine transposed with lateral incisor (Mx.C.I2), there are two major problems to be overcome: the ability the lateral incisor has to function as canine and the ability to disguise the canine in the position of lateral incisor [5]. The maxillary lateral incisor is not as favorable for canine guidance, since its root is usually thin and short. Thus, group disocclusion might be recommended for non-extraction cases. Maxillary canine reshaping usually requires a combination of incisal tooth wear and composite resin or dental veneer placement and may be an acceptable compromise [30]. In addition, the normally higher gingival contour of the canine, relative to the lateral incisor, may require a periodontal gingival recontouring procedure [26].

6.2.2. Correction of the Transposition

During maxillary transposition, the main difficulties in correcting altered tooth position are avoiding root interference and resorption and controlling root inclination of the transposed teeth. The width of the alveolus is usually insufficient for the roots of the teeth to pass labio-palatally particularly in canine-premolar transposition [5]. However, MAIA [31] has proven that it is possible to correct transposition between canine and maxillary lateral incisor.

Treatment mechanics and appliance design need to be individualized for each patient. This will depend on which teeth have erupted, when to pursue active traction or leave it passive, the periodontal status, and the three-dimensional tooth position to establish the direction of traction [19]. Different types of appliances have been described to resolve transpositions, such as sectional arches, springs, and transpalatal arches [32] (Figure 2).

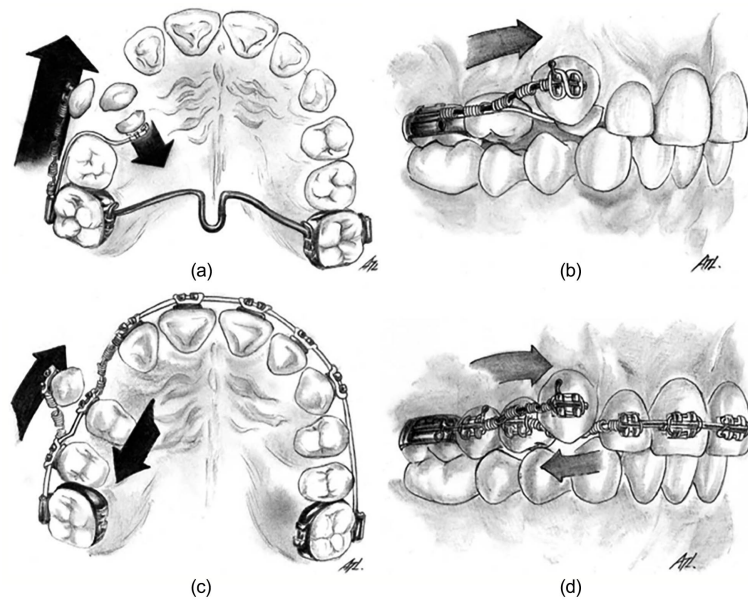


Figure 2. Transpalatal arch and springs used for correction of MxCP1 [33].

The mechanics for correcting tooth transposition involve 1) palatal displacement of either the lateral incisor or the first premolar, despite the possible cross-bite; 2) movement of the canine to its correct mesiodistal position, while in supraversion to diminish the possibility of root interference; 3) extrusion of the canine until it contacts its antagonist; 4) buccal repositioning of the palatally displaced tooth in the arch; and 5) finishing with bends for torque and inclination adjustment [28].

Techniques used to decrease the probability of further resorption caused by orthodontic treatment include 1) involving the lateral incisor in the archwire as late as possible in the orthodontic process, 2) using rectangular stainless steel wires for as little time as possible, and 3) using the torquing spring for less than 2 months [22].

Many types of anchorage may be used to help controlling the side effects of the mechanics, controlling anchorage and applying forces with the least amount of side effects possible (TADs, transpalatal arch, etc). Miniscrews can be of great help to both intrude and mesialize or distalize the canine [32].

6.2.3. Placement in Normal Position of the Transposed Canine with Extraction of the Adjacent Tooth

If the transposition is distal to the canine associated with dento-maxillary disharmony, the extraction of the maxillary first premolars, associated with the mandibular first or second premolars, restores the normal dental sequence within the arch.

When the transposition is mesial to the canine with dento-maxillary disharmony, extraction of the lateral incisor restores the normal dental sequence. The treatment is then similar to that of agenesis of the lateral incisor [32].

The adjacent tooth may be extracted in case of very advanced carious lesion, significant root resorption or periodontal disease.

In case of dysmorphism of the transposed tooth especially lateral incisor in maxillary transposition between canine and lateral incisor (Mx.C.I2.), the extraction of the hypoplastic lateral incisor restores the normal dental sequence. The treatment is then similar to that of agenesis of the lateral incisor [31].

6.2.4. Placement in Normal Position of Impacted Transposed Canine

The most appropriate method of surgical orthodontic management of these teeth is a closed surgical exposure technique [34]. The timing of orthodontic treatment is dependent on each individual case, but a good rule of thumb is to create space for the tooth and prepare the arch by leveling and aligning prior to surgical exposure. There are various techniques available to extrude the tooth such as sectional arch wires, utilities and additional vertical anchorage devices, namely palatal arches and modified palatal arches. In orthodontic terms, the canine position in all planes of space must be considered [35].

6.2.5. Transplantation of the Transposed Canine

Transplantation is a surgical technique consisting in entirely extracting the transposed canine in order to be transplanted into a neo-alveolus formed using

an implant drill instead of the temporary canine extracted during the same operation [36].

The indications for transplantation are limited. It requires sufficient space to transplant the canine by using the space of the temporary canine and space planning if necessary. The permanent canine must be free of any anomaly or lesion. The bone area should be free of any cyst, supernumerary germs, tumors in order to receive the tooth. The patient cooperation as well as an excellent oral hygiene is also required. Primary stability is ensured, if necessary, by a bonded metal retainer.

The technique is simple and effective. However, the prognosis is uncertain; a process of resorption of the apical third of root begins a few years later. Despite the risks of future ankylosis, the transplanted canine allows the preservation of the transverse and vertical bone, which may facilitate the placement of a future implant [37].

6.2.6. Abstention

If the transposed canine has not evolved and is located in a high-risk area for the adjacent teeth and roots and when placement is impossible without affecting the surrounding structures, abstention will be recommended in order to avoid resorptions, dehiscence, and recessions [24] [25].

6.2.7. Avulsion of the Transposed Canine

As for impacted canines, when infectious or neurological problems (paresthesias, pain) or root resorptions of adjacent teeth appear due to the transposed tooth, the indication of avulsion arises [25].

7. Conclusions

Dental transpositions can be challenging for orthodontists. A diagnosis based on clinical and radiological examination is effective and important in determining the appropriate treatment plan for the patient's transposed teeth. Many factors must be considered such as the patient's compliance, esthetics, function, and age to decide whether treatment of a transposition should involve tooth extractions, tooth alignment in the transposed order, or orthodontic correction of the transposition.

The correction and conservation of transposition have both advantages and disadvantages. Correcting the transposition may result in a natural and aesthetic arch form, a pleasant smile, and good architecture of the gingival margins. However, it includes long treatment time, the potential risk of root resorption of involved teeth, difficult torque control and a high risk of dehiscence and fenestration of supporting bone. Conserving transposition may be a good solution in some cases provided that some refinements are made.

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Conflicts of Interest

The authors declare no conflicts of interest.

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