

Management of Impacted Incisors Following Surgery to Remove Obstacles to Eruption: A Prospective Clinical Trial

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Abstract: **Purpose:** The purpose of this study was to assess the effectiveness of rapid maxillary expansion (RME) vs simply monitoring the eruption of permanent maxillary incisors following the surgical removal of obstacles to their eruption (supernumerary teeth, odontomas). **Methods:** Following surgical removal of the obstacles to incisor eruption (T1), 62 patients were randomly assigned to either the group to undergo RME (34 subjects; mean age 8 years, 11 months ± 11 months) or the group that was monitored without further treatment (28 subjects; mean age=9 years, 1 month ± 1 year). At T2 (1 year after T1), the prevalence rate of erupted incisors was recorded. Also, the time of eruption of the incisors and the amount of space loss were analyzed. **Results:** At T2, eruption of impacted incisors occurred in approximately 82 percent of the RME group cases vs approximately 39 percent of the monitored group cases (chi-square=10.43, P<.001). Time of eruption was significantly faster in the RME group, and anterior space loss significantly smaller. **Conclusions:** Rapid maxillary expansion treatment following surgical removal of the obstacles to the eruption of permanent maxillary incisors appears to be an efficient interceptive approach leading to eruption of the incisors in four out of five cases within seven months. (*Pediatr Dent* 2013;35:364-8) Received January 18, 2012 | Last Revision September 12, 2012 | Accepted September 12, 2012

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Failure of eruption of the permanent maxillary incisors is a pathologic condition of the early mixed dentition phase, which occurs in 0.2 percent to one percent of the population.^{1,2} Lack of eruption of one maxillary incisor requires either attentive monitoring or intervention when eruption of the adjacent incisor occurred six months before or when there is a definite deviation from the normal sequence of eruption.³⁻⁶

Supernumerary teeth and odontomas are the most common cause of failure of eruption.^{7,8} In cases of lack of eruption of maxillary incisors due to an obstacle, two possible approaches are possible once the obstacle has been removed. In one approach, the condition is monitored, with space maintenance on the upper arch.⁶ A prevalence rate of eruption of 54 percent to 64 percent has been reported at the end of the observation period.⁹⁻¹¹ A second approach, after surgical removal of the obstacle, is represented by orthodontic traction.^{12,13} This is accomplished following the creation of adequate space in the upper arch and creating a valid orthodontic anchorage system in the maxilla.² After surgical exposure of the tooth, orthodontic forces are applied to bring the impacted incisor into occlusion.^{14,15}

The complexity and costs of orthodontic treatment of unerupted maxillary incisors warrant study of possible interceptive treatment measures. Also, it would be desirable to assess the effectiveness of interceptive treatment within a relatively short period of time (one year) to perform the orthodontic traction at a time that is compatible with the physiologic development of occlusion.^{1,14} Most of the monitoring periods reported in the literature after removal of the obstacle to incisor eruption are characterized by a long duration (over two years), thus rendering orthodontic treatment and tooth repositioning more difficult and the cost-benefit

ratio less effective.^{6,14-16} The level of evidence for the clinical management of impacted maxillary incisors due to nonresorbable obstacles, however, is relatively low, as most studies are either case reports,^{2,7,17,18} case series,^{4,8} or retrospective studies with small sample sizes.^{1,5,10-12}

Interceptive procedures with the goal of facilitating eruption of displaced maxillary teeth include orthodontic treatment to maintain or increase maxillary arch length or perimeter.^{20,21} Maxillary expansion has been proposed as an alternative interceptive treatment for impacted incisors as a means to facilitate the eruption of the teeth after removal of the obstacles²²⁻²⁶ and has proven to be a favorable procedure to increase the eruption rate of palatally displaced canines, both in the early and late mixed dentitions.^{27,28}

The purpose of this study was to assess the effectiveness of rapid maxillary expansion (RME) following the surgical removal of obstacles to permanent maxillary incisors (supernumerary teeth and odontomas) vs monitoring the eruption of the teeth after surgical removal of the obstacles to eruption. The evaluation of the prevalence rate of successful eruption of the incisors in the two groups was accomplished within one year after the removal of the obstacle(s).

Methods

A total sample of 62 subjects (30 males, 32 females) with eruption disturbances of permanent maxillary incisors was enrolled in the study at the Departments of Orthodontics of the University of Rome "Tor Vergata," Rome, Italy, and the University of Florence, Florence, Italy. The sample presented with 74 impacted permanent incisors: 60 maxillary central incisors and 14 maxillary lateral incisors. The age range of the subjects was 8.1 to 11.2 years old. The study project was approved by the Ethical Committee at the University of Rome "Tor Vergata," and informed consent was obtained from the subjects' parents.

Additional enrollment criteria for the clinical trial were: Caucasian ancestry; the contralateral incisor had erupted at least six months before, or there was a deviation from normal sequence of eruption (lateral incisor erupted prior to the central incisor); presence of an obstacle such as supernumerary teeth or odontoma;

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absence of posterior cross-bite; skeletal age showing active phases of growth according to the cervical vertebral maturation method (CS1-CS3)²⁹; absence of previous orthodontic treatment or tooth extraction; and absence of craniofacial syndromes, cysts, cleft lip and/or palate, or multiple and/or advanced caries.

A panoramic radiograph was taken for all 62 subjects at the time of initial observation (T1), after which the obstacle to incisor eruption was surgically removed within two months. A second panoramic radiograph was performed for all subjects on average 10 months (range=8-12 months) after the surgical removal of the obstacle to eruption (T2). All subjects had dental casts both at T1 and T2.

Following the surgical removal of the obstacle to eruption, the 62 subjects were randomly divided by coin-toss into two groups: The first group of 34 subjects (15 males and 19 females, mean age=eight years, 11 months \pm 11 months) underwent RME that started one month after the removal of the obstacle to incisor eruption. Of these subjects, 24 patients were treated in Rome and 10 were treated in Florence. A rapid maxillary expander was used to solder the bands placed on the primary second molars or on the permanent first molars. Activation of the screw was continued until the palatal cusps of the maxillary posterior teeth were in contact with the buccal cusps of the mandibular posterior teeth.²⁵ The total amount of expansion was, on average, seven mm and was accomplished with a single activation of the screw per day. The primary goal for maxillary expansion in the sample was to improve the intraosseous position of the incisor.^{25,26} Following the retention period (six-seven months), the expander was removed and all cases were made available for clinical examination and panoramic radiograph at T2.

A second group of 28 subjects (15 males and 13 females, mean age=nine years, one month \pm 1 year) underwent only the surgical removal of the obstacle to incisor eruption, and they were then monitored with monthly appointments for 12 months thereafter (monitoring group).

The following measurements were performed on dental casts at T1 and at T2: maxillary intermolar width—the distance between the central fossae of the maxillary right and left first molars³⁰; mandibular intermolar width—the distance between the tips of the distobuccal cusps of the mandibular right and left first molars³⁰; transverse discrepancy between the arches at the level of the molars,³⁰ measured as the net difference between the maxillary intermolar width minus the mandibular intermolar width; maxillary intercanine width—distance between the cusps of the maxillary left and right canines³¹; and mandibular intercanine

width—distance between the cusps of the mandibular left and right canines.³¹ Transverse measures were performed with a dial caliper at 0.01 mm precision.

The analysis of space available vs space needed at the eruption site of the impacted incisor was also performed on the dental casts at T1 and T2 in each group.

On the panoramic radiographs, the measurement proposed by Bryan et al.⁹ was performed at T1 and T2 to evaluate the intraosseous displacement in terms of angulation of the incisors with eruption disturbance. They proposed to appraise the angle of the long axis of the unerupted permanent incisor to the midsagittal plane (Figure 1).

In this study, the dental maturity of the permanent maxillary incisor contralateral to the delayed maxillary incisor was estimated for each patient using the method described by Demirjian et al.³² to facilitate comparison between the dental and chronological ages of children under investigation.¹⁹ This method divides the formation of the crowns and roots of permanent teeth into eight stages (A-H).

The following outcome variables were recorded at T2:

1. Prevalence rate of erupted maxillary incisors. Unsuccessful outcome was a lack of eruption of the permanent incisor at T2, and unerupted teeth at T2 were considered candidates for surgical exposure and orthodontic traction.
2. For those patients showing eruption of the impacted incisors before T2, the time of eruption was recorded, since patients were observed once per month over the 1-year period from T1 to T2.

Statistical analysis. Reproducibility of the measurements on panoramic radiographs and dental casts was estimated by repeating all measurements and assessments for 30 patients after five months. Accuracy of the measurements was tested by using Dahlberg's³³ formula for the angle on panoramic radiographs and for the measures on dental casts. The method error was 0.4 degrees for the angular measurements and 0.15 mm for linear measurements on dental casts. With a sample size of 28 in each group, the power of the study was greater than 0.95 at an alpha level of 0.05.

The prevalence rates of cases with successful eruption of the impacted incisors at T2 were compared in the RME and monitoring groups by means of the chi-square test with Yates correction. The same test was used to evaluate the prevalence rate of subjects showing appreciable loss of space at the eruption site of the impacted incisors at T2. Student's *t* tests were employed to compare incisor intraosseous angulations at T1 and dental cast measurements at T1 and at T2 in the two groups. The same statistical test was applied to evaluate possible differences in the time of eruption following surgical removal of the obstacles in the two groups.

For statistical purposes, individual subjects and not individual incisors showing eruption disturbances were used as statistical units. From a methodological point of view, the examiner who appraised the eruption of the incisors at T2 in both groups, and also the possible loss of space at the eruption site of the impacted incisors at T2, was blinded concerning which group examined subjects belonged to.

Results

None of the subjects enrolled in the prospective clinical trial at the two centers of care dropped out of the study.

Of the 62 patients with impacted incisors, 26 subjects (42 percent) had supernumerary teeth and 36 (58 percent) had odontomas. For the 34 subjects who underwent RME, the average T2-T1 interval was 11 months \pm 11 months (mean age at T2=9 years, 10 months \pm 10 months). The 28

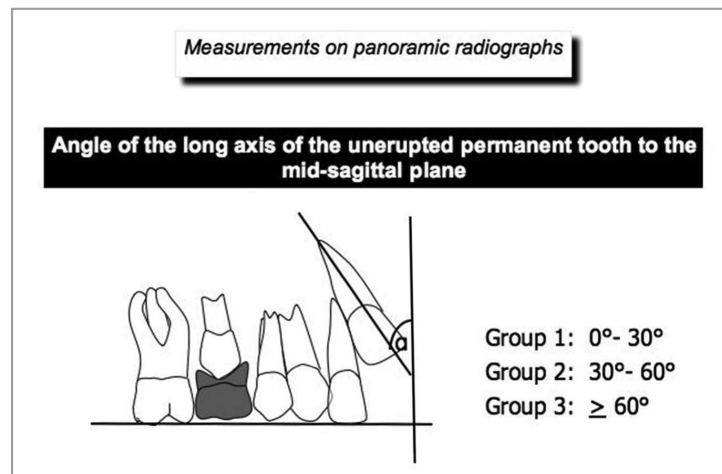


Figure 1. Measurements on panoramic radiographs.

subjects in the monitoring group were monitored with monthly appointments for 12±11 months (mean age at T2=10 years, one month±11 months).

When assessed in the two groups, the prevalence rate of supernumerary teeth as obstacles to incisor eruption was approximately 44 percent in the RME group and approximately 36 percent in the monitoring group, while the prevalence rate of odontomas was approximately 56 percent and 64 percent in the RME and monitoring groups, respectively (chi-square=1.14, *P*<.29). The distribution of obstacles to the eruption of the incisors in the two groups was not significantly different.

The average angulation of the impacted incisors in the panoramic radiographs at T1 in the RME group was 48±9.4 degrees, while it was 42.6±8.7 degrees in the monitoring group. No statistically significant difference between the two groups was found (*P*<.89).

The average amount of transverse discrepancy between the dental arches at T1 at the level of the first permanent molars was -2.2 mm (±1.4 mm SD) in the RME group and -1.8 mm (±1.3 mm) in the monitoring group. The transverse discrepancy at the level of the primary canines was -1.7 mm (±1.1 mm) in the RME group and -1.5 mm (±1.2 mm) in the monitoring group. No significant differences were recorded between the two groups (Table 1). The same measurements were recorded at T2. Both the maxillary intermolar and intercanine widths were significantly greater (*P*<.01) in the RME group than the monitoring group (±1.5 mm and ±2.0 mm, respectively). The posterior transverse discrepancy was 0.2 mm in the RME group, thus revealing a correction in the transverse interarch relationships, while it was still negative in the monitoring group. This difference was statistically significant (*P*<.001; Table 1).

In the total sample, the dental maturity of 74 permanent incisors (60 maxillary central incisors and 14 maxillary lateral incisors) was analyzed on the panoramic radiographs, according to the method by Demirjian et al.³² At T1, 50 incisors presented a stage F (7-9 years) of formation and 24 presented a stage G (9-10 years) of formation. At T2, 40 incisors presented a stage G and 34 a stage H (>10 years).

At T2, eruption of impacted incisors occurred in 28 out of 34 cases (-82 percent) of the RME group. Only six patients of this group required further surgical intervention and orthodontic traction following T2. Successful eruption of the impacted incisors in the monitoring group occurred in 11 of the 28 cases (-39 percent). The difference between the two groups was highly significant (chi-square=10.43, *P*<.001).

Only two out of 34 cases (-6 percent) in the RME group showed appreciable loss of space at the eruption site of the im-

acted incisor on the dental arch, while this occurred in 13 out of 28 cases (-46 percent) of the monitoring group. The difference was highly significant (chi square=11.64, *P*<.001). The loss of space was observed consistently in cases with failure of eruption of the impacted incisors in the monitoring group; however, no loss of space was assessed in four cases of the same group who did not show eruption of the impacted incisors.

The space at the eruption site was also measured on the dental casts at T1 and at T2, analyzing the distance from the mesial part of the contralateral erupted central incisor and ipsilateral lateral incisors. The mean width of the unerupted maxillary central incisors was 8.0 mm (±1.0 mm) in both groups, as derived from the width of the erupted contralateral central incisor. The amount of space available at the eruption site at T1 was 4.2 mm (±1.2 mm) in the RME group and 4.8 mm (±1.3 mm) in the monitoring group. This difference was not statistically significant. The same measurements were recorded at T2. In the RME group, the space at the eruption site was significantly greater than in the monitoring group (5.7 mm ±1.1 mm vs 4.7 mm ±1.2 mm, *P*=.001). Two of the 34 cases in the RME group showed a loss of space smaller than one mm, 20 subjects had an increase in space, and 14 had no change. In the monitoring group, 13 of the 28 subjects showed a loss of space greater than one mm, while 15 subjects had no change. No patients of this group showed an increase in space.

The average time of eruption of the impacted incisors after removal of the obstacle was 7.5±3.0 months in the RME group (which corresponds to 6.5 months after expansion), while the average time in the monitoring group was 9.5±3.5 months. This difference was statistically significant (*P*<.01).

Discussion

The present prospective clinical trial compared the outcomes of removal of the obstacle to eruption followed by RME treatment (in patients with impacted maxillary incisor due to supernumerary teeth or odontomas) with those of simply monitoring after removal of the obstacle. The targeted duration of time for the evaluation of the outcomes in terms of successful eruption of the impacted incisors in the two groups was 12 months.

No significant differences were present between the two groups at the beginning of the trial regarding age and gender distribution, skeletal maturation (all subjects were prepubertal in both groups),²⁹ prevalence rate for type of obstacle to incisor eruption, severity of intraosseous displacement of the maxillary incisors, and amount of transverse discrepancy of the dental arches.

The results of the study indicate that the RME group presented with a significantly greater prevalence rate (-82 percent) of eruption of previously impacted incisors than the monitoring

Table 1. DENTAL CAST MEASUREMENTS FOR THE RME GROUP VS THE MONITORING GROUP AT T1 AND T2*

Dental cast measurements	RME group T1	Monitoring group T1	t test	RME group T2	Monitoring group T2	t test
	T1±(SD)	T1±(SD)		T2±(SD)	T2±(SD)	
Maxillary intermolar width (mm)	43.3±2.5	44.2±1.9	NS	46.4±2.2	44.9±1.7	†
Mandibular intermolar width (mm)	45.5±2.2	46.0±1.5	NS	46.2±1.9	46.5±1.5	NS
Posterior transverse discrepancy (mm)	-2.2±1.4	-1.8±1.3	NS	0.2±2.0	-1.4±1.5	‡
Maxillary intercanine width (mm)	35.5±0.9	36.2±1.1	NS	39.0±1.2	37.0±1.1	‡
Mandibular intercanine width (mm)	37.2±0.5	37.7±0.8	NS	38.3±0.9	38.0±0.8	NS

*RME=rapid maxillary expansion; T1=time of initial observation, after which the obstacle to incisor eruption was surgically removed within 2 months; T2=time of surgical removal of the obstacle to eruption; NS=nonsignificant.

†*P*<.01. ‡*P*<.001.

group (~39 percent). Approximately, four out of five subjects treated with the application of a rapid maxillary expander showed successful eruption. Conversely, approximately two of three subjects with impacted maxillary incisors who underwent only monitoring after the surgical removal of the obstacle to eruption failed to present with eruption of the teeth. Beyond the very significant difference in effectiveness, there was also a notable difference in the efficiency of the outcomes, since eruption of the impacted incisors in the RME group occurred approximately two months earlier than in the monitoring group. These results would allow for a more timely decision to intervene with orthodontic traction in cases treated with RME showing failure of eruption of the maxillary incisors.

The mechanism of space preservation or space increase in the anterior segment of the maxillary arch is probably an important factor leading to more favorable outcomes in the RME group. Conversely, the frequent loss of space in the anterior region observed in the monitored group accounts for a large number of the cases that failed to show eruption of the impacted incisors. Some additional mechanism has to be involved in the favorable effects of RME at the dentoalveolar and skeletal level in terms of facilitation of tooth eruption, however, since four of the subjects of the monitoring group maintained the space on the maxillary arch at the site of expected eruption of the incisor, but did not show the emergence of the impacted teeth during the observation period. The significant effects of RME on the eruption of palatally displaced canines have been well demonstrated in the literature.^{16,20-24}

The analysis of space available vs space needed at the eruption site of the impacted incisor on dental casts at T2 showed that all patients in the study had maxillary anterior space deficiency: Mean space available at the eruption site was 5.7 mm in the RME group and 4.7 mm in the monitoring group, while mean width of the unerupted tooth was 8.0 mm. The present therapeutic protocol (surgical removal of the obstacle followed by RME) is valid to improve the intraosseous position of the impacted teeth, but it is inefficient to completely resolve the anterior space deficiency and recover the correct position of the delayed incisor. In many cases, therefore, further orthodontic treatment with fixed appliances to finalize the occlusion will be necessary.

In this study the surgical removal of the obstacle in all 62 subjects was performed immediately after the first examination (8.1-11.2 years old). Each surgeon removed the odontoma or the supernumerary tooth attempting to minimize the surgical trauma with minimal effect on the unerupted incisor. Intraoperative variables could have been responsible for some variations in the treatment response.

The chronologic age of the analyzed sample is greater than that indicated by Omer et al.¹⁹ as optimal for the removal of an obstacle to eruption (6-7 years old). Dental eruption, however, should be evaluated according to dental maturity rather than chronologic age.¹⁹ All 74 incisors analyzed were either in stage F or stage G of root formation, which is before the complete maturity of the roots. These data did not completely agree with Omer et al.,¹⁹ who reported that early removal of an obstacle (supernumerary teeth or odontoma) seems to be advantageous before complete root formation (up to the stage G), after which more complications are expected. Younger patients would be expected to respond more favorably in both groups.

These results offer preliminary evidence for this methodology. Future studies on larger groups of subjects with impacted incisors may be able to assess possible predictors in terms of intraosseous displacement of the impacted incisors on the final outcomes of tooth eruption in patients undergoing interceptive treatment with RME. We believe the ideal treatment for impacted incisors is identification of obstacles to eruption at an earlier age

followed by early surgical intervention; the present therapeutic protocol could be considered for those patients who have missed the optimal window for intervention. Also, the effects of alternative interceptive treatment procedures to increase maxillary arch perimeter or depth could be evaluated with respect to RME.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Rapid maxillary expansion following surgical removal of the obstacles to the eruption of permanent maxillary incisors (supernumeraries and odontomas) appears to be an effective and efficient interceptive approach, leading to successful eruption of the incisors in approximately 82 percent of the cases over an average time of six to seven months postexpansion.
2. When no RME treatment was performed following surgical removal of obstacles to the eruption, spontaneous eruption of impacted incisors occurred in approximately 39 percent of the cases, with most cases showing loss of space in the incisor region of the dental arch.

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