Postretention Study: Incidence and Stability of Rotated Teeth in Humans

William D. Swanson, D.D.S., M.S.D.
Richard A. Riedel, D.D.S., M.S.D.
James A. D'Anna, D.D.S.

Nearly every orthodontic textbook or research paper written on the topic of retention contains a few paragraphs on the difficulties of retaining orthodontically rotated teeth. The literature is replete with discussions of factors important to increasing the stability of such teeth. Angle[1] believed early treatment and long term retention were necessary whereas Skogsborg[2] attempted to increase stability by vertically slicing interdental bone. Other authors have described the contributions of such factors as occlusion, musculature, and fibers of the periodontium to the relative stability of orthodontically rotated teeth. The wide range of proposed treatment procedures usually includes a common denominator of three recommendations: early treatment, surgical interruption of the supra-alveolar fibers and long-term retention. In recent years substantial attention has been directed toward surgical procedures such as gingivectomy and transection of supra-alveolar fibers.[3-6] Unfortunately, most studies incorporating these techniques are deficient in control sample size. In addition, the relationship between growth effects, extraction versus nonextraction treatment, and the severity of original malocclusions on post-treatment stability of orthodontically rotated teeth has not attracted sufficient consideration.

The purpose of this study is to examine these questions in a large sample of orthodontically treated malocclusions not less than ten years out of retention.

Materials and Methods

The original sample was comprised of initial, end of treatment, and post-retention dental casts from 116 orthodontically treated malocclusions. These cases were selected from records of patients treated at the University of Washington Graduate Orthodontic Clinic and from patients treated in the private practice of Dr. R. A. Riedel. To achieve compatibility with the statistical technique used, only those cases treated nonextraction, or by means of first bicuspid extraction in one or both arches were selected. This resulted in a distribution of 92 cases for the maxillary arch and 75 cases for the mandibular arch (Table I).

Dental casts

Cusp tip, cingulum, midincisal and midpalatal raphe points were marked on the casts (Fig. 1). Two midpalatal raphe points were selected, one between the most anterior rugae and the second, the most distal raphe anatomical landmark visible on the cast. The midpalatal plane was transferred to the mandibular casts by means of a symmetriscope.

Points were placed with all three casts from the same case (initial, end of treatment and postretention) positioned side by side to facilitate identification of the same anatomical marks on each cast. Coordinates of the selected points were recorded by digitizing techniques[7,8] and subsequently stored on magnetic tape. Computer technique was employed to assess the rotational position of each tooth by constructing

TABLE I

Distribution of the sample

	First Bicuspid Extraction				*Nonextraction*			
	Maxillary		*Mandibular*		*Maxillary*		*Mandibular*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Class I	10	16	7	11	2	4	2	5
Class II-1	12	22	9	12	8	7	10	10
Class II-2	5	3	3	1	2	1	4	1
Totals	27	41	19	24	12	12	16	16

Total maxillary cases = 92 (53 females, 39 males)
Average age at end of treatment = 15 years, 05 months
Total mandibular cases = 75 (40 females, 35 males)
Average age at end of treatment = 16 years, 02 months

a straight line through the proper points and measuring its angular relationship with the midpalatal raphe.

Cephalometric roentgenograph

Using Simons' method, partial tracings of the maxilla and mandible were made on acetate tracing paper.[9] Measurements were made from the tracings at each time period to determine growth. In the mandible a straight line measurement from point Ar to point Po was used. For the maxilla a line was constructed perpendicular to the palatal plane (ANS-PNS) through the midpoint between the inferior apices of the PTM shadows. The distance along the palatal plane from ANS to the intersection with the perpendicular line was then measured. All measurements were stored on magnetic tape.

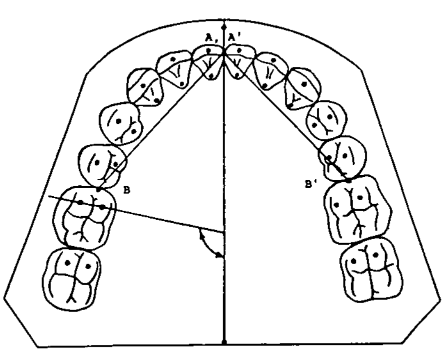

Fig. 1 Method of arch length (A-B, A'-B') and angular measurements on mandibular casts. Angular measurements were made relative to the midpalatal raphe plane.

Statistical analyses

The maxillary and mandibular arch data were analyzed separately by means of a multivariate general linear hypothesis computer program. The purpose of this analysis was to ascertain whether patient membership in various subgroups (sex, age, growth, classification, extraction or nonextraction, and arch length change) and amount of tooth rotation during the treatment period affected the stability of orthodontically rotated teeth in the postretention period.

Incidence of rotations in the pretreatment and postretention periods was determined by calculating arithmetic means for each rotational severity category.

Findings

Multivariate analysis

The multivariate general linear hypothesis analysis findings indicated that age, sex, classification, presence of extractions, and growth of the maxilla or mandible had no effect on rotations found at the end of the postretention period. Their regression coefficients were judged to be not significantly different from zero.

Significant effects observed were that the rotational position of any individual tooth before orthodontic treatment or during the postretention period seldom affects the rotational position of any other tooth in the same arch during these two time periods. However, the amount of rotational change experienced by a tooth through orthodontic treatment may well affect the amount of rotational change (relapse) in the same tooth during the postretention period.

Incidence of rotations and relapse

Each tooth was categorized before treatment and postretention according to the amount of angular change that would be required to rotate it into a proper contact relationship with the adjacent teeth. The rotational categories used were mild (0°-10°), moderate (>10°, <20°) and severe (>20°).

The majority of pretreatment rotations in both arches fell into the mild (0°-10°) category. The pretreatment incidence of moderate (>10°, <20°), and severely (>20°) rotated teeth in untreated cases when combined was found to be as follows (descending order of percentage frequency):

Maxillary

1. cuspids (49.5)
2. second bicuspids (29.8)
3. lateral incisors (20.1)
4. central incisors (16.8)
5. first molars (16.3)

Mandibular

1. cuspids (40.0)
2. second bicuspids (38.0)
3. lateral incisors (29.3)
4. central incisors (15.3)
5. first molars (12.6)

At the end of the ten year postretention period the majority of teeth were mildly rotated regardless of the severity of the rotational correction required during orthodontic treatment. The remainder of the teeth were distributed in the moderate category with a few in the severely rotated range. Basically, the greater the correction required during orthodontic treatment, the greater the rotational relapse.

The distribution of teeth that would require moderate and severe rotational corrections ten years postretention is shown for each arch as follows (descending order of percentage frequency:

Maxillary

1. cuspids (20.1)
2. lateral incisors (12.0)
3. second bicuspids (9.8)
4. central incisors (4.9)
5. first molars (2.7)

Mandibular

1. cuspids (28.7)
2. second bicuspids (18.7)
3. first molars (14.0)
4. lateral incisors (11.3)
5. central incisors (8.7)

Discussion

The findings in this study suggest that certain teeth tend to undergo more rotational relapse than others. This tendency is apparently unaffected by such parameters as sex, age at the end of treatment, classification, bicuspid extractions, arch length changes, and growth of the jaws, but is very likely influenced by the amount of rotational correction experienced by the tooth during orthodontic treatment.

Rotational changes in general

The incidence of individual tooth rotation in typical malocclusions demonstrates that cuspids are the most frequently rotated teeth, in both arches, in the pretreatment and postretention periods. Another finding of significant clinical importance is that the amount of relapse experienced by an orthodontically rotated tooth is directed proportional to the amount of rotational correction applied during treatment.

The mild (0°-10°) rotational category accounted for most of the relapse for all teeth in both arches. This is to be expected since the bulk of the sample fell into the mild rotation treatment category. Contradicting this are the few initially mildly rotated teeth that relapsed into a moderate or severely rotated postretention category. Speculation on the etiology of such a relapse pattern would lead the authors to suspect mesial forces within the arch rather than the pull of periodontal fibers. Possibly these forces, if active in an arch where rotations were not fully corrected (or left overcorrected) during treatment, could have caused a further turning of the tooth away from an ideal contact relationship with adjacent teeth.

Age

Reitan[10,11] and Case[12] proposed that stability of rotated teeth is enhanced by means of early correction. The multivariate regression analysis findings in this study do not support this proposal, but this may be due to an insufficient age spread of the sample subjects at the end of treatment with too few cases in the younger age bracket.

Growth

Litowitz[13] studied the movements of lower incisor teeth and maxillary and mandibular first permanent molars during treatment and in the postretention period. He found that cases exhibiting the greatest amount of growth during treatment underwent the least amount of relapse. Huckaba[14] agreed with these findings. Riedel[15] said growth may be an aid in the correction of many types of orthodontic problems and it also may cause relapse of treated cases. These references dealt with retention and relapse of various tooth movements, not rotations specifically. However, Hixon and Sanin[16] correlated the effects of several arch parameters on rotation of maxillary permanent incisors in nonorthodontically treated children and found no relationship between rotational changes and growth of arch dimensions.

The findings of the present study would tend to agree with the conclusions of Hixon and Sanin since no relationship was found to exist between stability of orthodontically rotated teeth and growth during the treatment or postretention periods.

Arch length and extractions

Most authors seem to agree that arch length shortens with time. Nance[17] found that mandibular incisors ultimately shift to positions of equilibrium with the forces acting upon them. This relapse is associated with a shortening of arch length. Hixon and Sanin found arch length change did not correlate as a cause of rotational relapse of maxillary incisors. Dona[18] analyzed dental casts from before and after treatment and found 54% of rotations returned in the nonextraction cases and 57% returned in the extraction cases. These findings would support the present conclusions that neither arch length changes nor extraction of bicuspids have an effect on postretention stability of orthodontically rotated teeth.

Relapse vs initial malocclusion

There is some controversy about whether the amount of rotational relapse is affected by the severity of the initial rotation. Boese[19] found that per cent relapse was not directly related to the degree of rotation applied to his study teeth. Conversely, Wiser[20] reported a direct relationship between relapse and initial rotation. This study would agree with Wiser's findings that amount of rotational relapse is a direct indication of severity of the initial rotation.

Early correction

Reitan[21] compared the response of bone tissue in children and adults and found that adult tissues are predominantly in a static phase before treatment, with fewer cellular elements plus stronger and thicker fiber bundles. These factors largely account for the slower response of adult tissues to application of orthodontic forces. Similarly, Reitan pointed out that movement of a tooth during root development may increase posttreatment stability. Since the supporting tissues were in a stage of proliferation during orthodontic movement, the new fibers formed during this stage would naturally enhance maintenance of the new tooth position.

The age level of subjects used in the present study prevented an evaluation of Reitan's theory since root development essentially would have been complete prior to the initiation of orthodontic treatment.

Overall view

Fibers of the periodontium have been cited in the literature as a cause of relapse of orthodontically rotated teeth. Various methods of enhancing the stability of these teeth have also been studied and the one perhaps showing the most promise is Edwards' sulcular incision.[6] Other techniques of surgically interrupting supra-alveolar fibers by means of simple gingivectomy were studied by Allen[4] and showed promising results but proved too radical for routine practice. The present study did not involve patients who had been subjected to any of the surgical procedures, so a direct evaluation of these methods cannot be made.

Most of the subjects in the present study were held in retention for over a year with removable appliances in the maxillary arch and usually a fixed retainer (cuspid to cuspid) in the lower arch. Even though some of the fixed retainers were in place beyond three years, it is interesting to note the high incidence of mandibular cuspid relapse in the postretention period. The retention data available from patient history charts were not complete enough to allow any conclusions on stability of rotated teeth versus duration and quality of retention. However, in view of suggestions in the literature that reorganization of periodontal fibers is a slow process, one would have to believe that surgical intervention and long term retention are the best clinical tools available at the present time for enhancing the stability of orthodontically rotated teeth.

Summary and Conclusions

Computerized measurements from pretreatment, end of treatment, and postretention models and cephalometric roentgenograms of orthodontically treated cases at least ten years out of retention were studied by statistical analyses. Multivariate regression techniques were used to relate growth, sex, age at end of treatment, classification, extraction or nonextraction, and arch length changes with rotational changes during the treatment and postretention periods. This was done for ten permanent teeth in each arch, excluding first bicuspids, second and third molars. The incidence of pretreatment rotations and postretention rotational relapse was also determined for each of the ten teeth.

School of Dentistry
Univ. of Washington
Seattle, Wash. 98195

References

1. Angle, E. H.: *Treatment of Malocclusion of the Teeth.* 7th Edition, S. S. White Dental Manufacturing Company, Philadelphia, 1907.
2. Skogsborg, C.: The permanent retention of the teeth after orthodontic treatment. *Dental Cosmos,* 69: 1117-1129, 1927.
3. Boese, L. R.: Increased stability of orthodontically rotated teeth following gingivectomy. M.S.D. Thesis, Univ. of Washington, 1968.
4. Allen, R. L.: A study of the regression phenomenon of orthodontically rotated teeth in the human patient with and without surgical removal of the supra-alveolar fiber apparatus. M.S.D. Thesis, Univ. of Washington, 1969.
5. Collins, A. P.: Influence of the gingival fiber complex on the relapse of orthodontically repositioned teeth in young rhesus monkeys. M.S.D. Thesis, Univ. of Washington, 1969.

6. Edwards, J. G.: A surgical procedure to eliminate rotational relapse. *Am. J. Orthodont.*, 57:35-46, 1970.
7. van der Linden, F. P.: *Manual for the Analysis of Dental Casts With the Optocom.* Second Edition, Ann Arbor, Michigan, 1971.
8. Erickson, J. D.: Quantitating human palatal morphology. *Archs. Oral Biol.*, 17:339-348, 1972.
9. Simons, M. E.: *Change in Overbite: A Ten Year Postretention Study.* M.S.D. Thesis, Univ. of Washington, 1971.
10. Reitan, K.: Tissue rearrangement during retention of orthodontically rotated teeth. *Angle Orthodont.*, 29: 105-113, 1959.
11. ————: Principles of retention and avoidance of posttreatment relapse. *Am. J. Orthodont.*, 55:776-790, 1969.
12. Case, Calvin S.: *Technics and Principles of Dental Orthopedia and Prosthetic Correction of Cleft Palate.* C. S. Case Co., Chicago, 382-383, 1921.
13. Litowitz, R.: A study of the movements of certain teeth during and following orthodontic treatment. *Angle Orthodont.*, 18:113-132, 1948.
14. Huckaba, G. W.: The physiologic basis of relapse. *Am. J. Orthodont.*, 38:335-350, 1952.
15. Riedel, R. A.: A review of the retention problem. *Angle Orthodont.*, 30:179-199, 1960.
16. Hixon, E. H., Sanin, C.: Axial rotations of maxillary permanent incisors. *Angle Orthodont.*, 38:269-283, 1968.
17. Nance, H. N.: The limitations of orthodontic treatment. *Am. J. Orthodont. and Oral Surg.*, 33:253-301, 1947.
18. Dona, A.: An analysis of dental casts of patients made before and after orthodontic treatment. M.S.D. Thesis, Univ. of Washington, 1952.
19. Boese, L. R.: Increased stability of orthodontically rotated teeth following gingivectomy. M.S.D. Thesis, Univ. of Washington, 1968.
20. Wiser, G. M.: Surgical resection of supra-alveolar fibers and the retention of orthodontically rotated teeth in the dog. M.S.D. Thesis, Temple Univ., 1961.
21. Reitan, K.: Clinical and histologic observations on tooth movement during and after orthodontic treatment. *Am. J. Orthodont.*, 53:721-745, 1967.