A meta-analysis of mandibular intercanine width in treatment and postretention

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In orthodontics, the stability of the achieved result remains a fundamental issue of concern and debate. Postretention results tend to function as a crude tool for measuring quality both in diagnosis and treatment. Tirk[1] succinctly captured this philosophy, saying: "The result of orthodontic therapy—good, bad or indifferent—is only evident many years out of retention."

One issue of treatment and stability that has traditionally created much debate is the purported inviolability of the mandibular arch form. Many clinicians and researchers believe that the mandibular arch form represents a state of structural and functional balance for the individual and that it should not be altered in treatment.

The concept of the mandibular intercanine dimension as a stable and basically inviolable measurement has been supported repeatedly in the literature.[2-14] A substantial number of clinical studies on postretention results reflect the validity of this notion based on statistical findings.[4,15-25] However, some in the profession contend that the mandibular arch form can be successfully expanded to increase arch length availability for the dentition. Vast anecdotal evidence[26,27] as well as published clinical studies[28-31] support the success of the expansion treatment modality.

A significant number of clinicians and researchers who otherwise seek to avoid expansion of mandibular intercanine width have mentioned

Abstract

The meta-analysis technique of literature review was applied to a total of 26 previous studies to assess the longitudinal stability of postretention mandibular intercanine width. Weighted averages and standard deviations for the means of 1,233 subjects were compared for linear changes in intercanine transverse dimensions during treatment (T1), immediately after treatment (T2), and after removal of all retention (T3). Net change was defined as the difference between means at T3 and T1. Dimensional changes were also evaluated on the basis of patient pretreatment Angle classification, extraction, and nonextraction treatment modalities of each group. Paired two-tail *t*-tests were performed between T3 and T1 means on all groups at the *a priori* level of significance set at a ≤ 0.05. Statistically significant differences were observed for the following groups: all patients; nonextraction; extraction; Class I; Class I extraction; Class II extraction; and, Class I Division 1 nonextraction. The findings of this study indicate that regardless of patient diagnostic and treatment modalities, mandibular intercanine width tends to expand during treatment on the order of one to two millimeters, and to contract postretention to approximately the original dimension. While statistically significant differences could be demonstrated within various groups, the magnitudes of the differences were not considered clinically important.

Key Words

Meta-analysis • Intercanine • Posttreatment • Postretention

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Table 1
Studies, samples sizes, and corresponding mean intercanine changes (in mm)

Paper	Max. yrs retention-free	Total subjects	Nonextr. patients	Extr. patients	Class I patients	Class II patients	Class II div 1	Class II div 2	Class I nonextr.	Class I extr.	Class II nonextr.
Litowitz[29]	1	19	19								
Dona[17]	2	8	8								
	2	4		4							
Peak[47]	0.5	23		23	23					23	
	0.5	7		7		7					
	0.5	13	13			13					13
Steadman[23]	1	15	15								
	1	7		7							
Amott[2]	4	26	26		26				26		
	4	12	12			12	12				12
	4	17	17			17		17			17
Walter[31]	1	50	50								
	1	50		50							
Arnold[15]	5	20	20								
	5	13		13							
Welch[25]	5	34		34							
Hernandez[37]	0.5	58	58			58	58				58
	0.5	25		25		25	25				
Davis[36]	3	16	16		16				16		
	3	30		30	30					30	
	3	9	9			9					9
	3	11		11		11					
Renger[48]	1	25	25								
Bishara[35]	0.5	33	33								
Shapiro[12]	10	5	5		5				5		
	10	23		23	23					23	
	10	14	14			14	14				14
	10	29		29		29	29				
	10	3	3			3		3			3
	10	6		6		6		6			
Kuftinec[21]	0.33	20	20								
	0.33	30		30							
Hechter[20]	2	7	7		7				7		
	2	12		12	12					12	
	2	8	8			8	8				8
	2	20		20		20	20				
	2	4	4			4		4			4
	2	4		4		4		4			
Gardner[18]	1	74	74								
	1	29		29							
Johnson[6]	8.8	1	1		1				1		
	9.7	1		1	1					1	
	8.8	2		2		2					
	11.5	1	1			1					1
El-Mangoury[4]	2	25									
	2	25									
Boese[16]	4	40									
Herberger[28]	2	56	56								
Uhde[24]	12	18	18		18				18		
	12	18		18	18					18	
	12	27	27			27					27
	12	9		9		9					
Glenn[19]	3	14		14	14					14	
	3	14		14		14					
Sandstrom[30]	2	17									
McReynolds[49]	10	32		32							
Paquette[50]	9	30	30			30					30
	9	33		33		33					
Luppanapor[51]	10.8	27	27			27					27
	10.8	30		30		30					
Totals	1233	616	510	194	413	166	34	73	121	223	190

Table 1, continued

Class II extr	Class II div 1 nonextr	Class II div 1 extr	Class II div 2 nonextr.	Class II div 2 extr	Mean IC change T2 - T2	Mean IC change T2 - T3	Mean IC change T1 - T3	PRF retention-free yrs.	Weighted mean change T2 - T3
					2.95	-1.18	1.76	19	-22.42
					0.75	-0.41	0.34	16	-6.56
					1.28	-2.3	-1.03	8	-18.4
					2.43	-0.81	1.62	11.5	-9.315
7					2.37	-0.8	1.57	3.5	-2.8
					0.98	-0.26	0.71	6.5	-1.69
					1.86	-0.53	1.33	15	-7.95
					2.63	-0.57	2.43	7	-3.99
					2.03	-1.69	0.34	104	-175.76
	12				1.53	-1.48	0.06	48	-71.04
			17		2.17	-1.66	0.51	68	-112.88
					2.02	-1.16	0.86	50	-58
					2.05	-1.62	0.43	50	-81
					1.18	-1.44	-0.27	100	-144
					1.05	-0.96	0.01	65	-62.4
					2.28	-1.76	0.52	170	-299.2
	58				0.92	-1.07	-0.15	29	-31.03
25		25			2.35	-1.04	1.31	12.5	-13
					2.15	-1.19	0.59	48	-57.12
					2.13	-1.34	0.8	90	-120.6
					1.42	-1.97	-0.54	27	-53.19
11					2.31	-1.71	0.6	33	-56.43
					0.47	-0.62	-0.16	25	-15.5
					0.77	-0.55	0.22	16.5	-9.075
					1.3	-1	0.3	50	-50
					1.9	-2.1	-0.2	230	-483
	14				0.2	-1.4	-1.2	140	-196
29		29			1.2	-1.9	-0.7	290	-551
			3		2	-2	0.1	30	-60
6				6	2.7	-1.3	1.4	60	-78
					0.1	-0.4	-0.3	6.6	-2.64
					2.5	-0.6	1.9	9.9	-5.94
					0.3	-0.3	0	14	-4.2
					0.8	-0.9	-0.1	24	-21.6
	8				0	-1.1	-1.1	16	-17.6
20		20			1	-1.4	-0.4	40	-56
			4		1.4	-1.2	0.2	8	-9.6
4				4	0.1	-0.5	-0.4	8	-4
					1.23	-0.72	0.51	74	-53.28
					1.92	-1.13	0.76	29	-32.77
					1.5	0	1.5	8.8	0
					-1	-1.5	-2.5	9.7	-14.55
2					1	-0.75	0.25	17.6	-13.2
					0.5	-0.5	0	11.5	-5.75
					0.74	-0.42	0.32	50	-21
					1.56	-1	0.56	50	-50
					0.8	-1.2	-0.4	160	-192
					2.76	-1.9	0.86	112	-212.8
					1.89	-2.53	-0.64	216	-546.48
					2.84	-2.07	0.77	216	-447.12
					2.27	-2.08	0.19	324	-673.92
9					1.38	-2.25	-0.87	108	-243
					0.5	-1	-0.5	42	-42
14					0.8	-1	-0.2	42	-42
					2.2	-1	1.1	34	-34
					0.7	-1.8	-1.1	320	-576
					1.1	-0.6	0.5	270	-162
33					2.2	-1.2	1	297	-356.4
					0.8	-1.4	-0.6	291.6	-408.24
30					1.4	-1.5	0	324	-486
92	74	24	10						

Table 2
Comparison of mean intercanine width changes before and after treatment

	Patient N	Mean treatment change (mm) (T1-T2)	Mean postretention change (mm) (T2-T3)	# samples +/ # no change/ # samples - (T1-T3)	Mean net changes (mm) (T1-T3)	Standard deviation (T1-T3)	Degress of freedom (T1-T3)	95% confidence Interval (T1-T3)	*p*-value (T1-T3)
All patients	1233	1.57	-1.24	34+/ 3'0'/ 21-	0.33	1.77	391	(.23, .43)	0*
Nonextraction	616	1.45	-1.17	18+/ 2'0'/ 9-	0.28	1.79	237	(.14, .41)	0.0001*
Extraction	510	1.78	-1.41	15+/ 1'0'/ 11-	0.39	1.67	153	(.26, .55)	0*
Class I	194	1.86	-1.48	7+/ 1'0'/ 5-	0.36	2.15	94	(.55, .66)	0.0228*
Class II	413	1.40	-1.32	13+/ 2'0'/ 10-	0.09	1.61	151	(-.06, .24)	0.2762
Class II, Div 1	166	1.13	-1.31	2+/ 5-	-0.18	1.61	94	(-.42, .68)	0.1601
Class II, Div 2	34	1.91	-1.44	4+/ 1-	0.49	1.68	16	(-.12, .1.09)	0.1122
Nonext, Class I	73	1.80	-1.60	4+/ 1'0'/ 1-	0.13	2.79	41	(-.53, .79)	0.6843
Ext, Class I	121	1.90	-1.41	3+/ 4-	0.49	1.43	52	(.23, .76)	0.0003*
Nonext, Class II	223	1.19	-1.26	1+/ 1'0'/ 5-	-0.07	1.41	108	(-.25, .11)	0.4457
Ext, Class II	190	1.64	-1.39	6+/ 1'0'/ 5-	0.27	1.81	42	(0.0, .53)	0.0444*
Non, Class II/1	92	0.81	-1.20	1+/ 3-	-0.40	1.42	69	(.07, .66)	0.0155*
Ext, Class II/1	74	1.50	-1.50	1+/ 2-	0.10	1.68	24	(-.34, .46)	0.7632
Non, Class II/2	24	2.02	-1.60	3+	0.41	1.68	16	(-.32, 1.13)	0.2558
Ext, Class II/2	10	1.66	-1.00	1+/ 1-	0.68	-	-	-	-

* $p < 0.05$

potential exceptions to their rule of canine width maintenance. Most notably, various authors have implied that intercanine expansion may be better tolerated in Class II,[32] Class II Division 1,[33] Class II Division 2,[2,12,34] Class II extraction,[11] and Class II Division 2 extraction[10] cases than in Class I patients.

Clinicians who oppose expansion will, in some cases, have to extract teeth. As the canines are retracted into the extraction site, intercanine width increases because the alveolar process is in a wider part of the arch. Thus, the clinician who extracts teeth to avoid expanding intercanine width actually causes width to increase. Strang[14] referred to this change as "buccal movement" of the canines, to distinguish it from traditional expansion. Numerous researchers have supported the notion that intercanine width can be increased if the canines are moved distally on the alveolus into an extraction site.[11,21,35-38]

The role of meta-analysis

Given the variability of information published on the subject of arch expansion, a general review of the literature can generate as much confusion as clarity. Traditional research reviews have been labeled subjective, inefficient, and often scientifically unsound when they overlook the differences in quality of the literature reviewed.[39] These research reviews are also hindered by the variability in the studies, and they fail to reach firm conclusions as a result.[40]

Meta-analysis is defined as "the statistical analysis of a large collection of results from individual studies for the purpose of integrating findings."[41] Meta-analysis serves as a structured approach to a literature review that allows results from disparate studies to be combined for greater statistical power than the independent studies alone can provide. As reported by L'Abbe et al.,[42] "For clinical research, the main objective of meta-analysis is to arrive at a general conclusion."

The purpose of this investigation was, first, to gather all the clinical studies that quantify intercanine dimension before and after orthodontic treatment and after some period without retaining devices; second, to establish a means of comparing these studies so that data could be integrated for greater clinical relevance via meta-analysis; and third, to propose a baseline for postretention canine adjustment of orthodontic cases based on Angle classification and whether treatment was extraction or nonextraction.

Materials and methods

Meta-analysis was developed for use in the social sciences and has recently been applied to the dental literature.[43-46] This study was formulated according to the five steps listed by Cohen.[39]

Inclusion criteria

Specific criteria were formulated to ensure that necessary characteristics were present in each study incorporated into the meta-analysis. These inclusion criteria were established as follows:

1. Numerical data must be available to show changes in intercanine width from pretreatment (T1) to immediate posttreatment (T2), and from posttreatment to postretention (T3). Therefore, net change in intercanine dimension from pretreatment to postretention (T1 to T3) could also be calculated. The dimension was to equal the shortest linear distance on casts either from the cusp tip of one canine to that of its antimere, or from any other reproducible landmark of one canine to that of its antimere. Alternatively, this dimension could be measured from photocopies or other photographic reproductions of the occlusal aspect of original study models.

2. The report must contain adequate information regarding the number of subjects in the study and the minimum period between discontinuation of retention devices and postretention records for any given member of that study.

3. All data must derive from studies reported in published literature or in unpublished graduate theses from accredited orthodontic programs.

4. Data must not derive from another study being used in the meta-analysis. To avoid duplication of data (and adding excessive statistical weight to a particular patient pool) the source of the patients from which the data was collected for each study was evaluated. When more than one study used the same patient records, only the data from the original paper was used.

Locating studies

Published studies were located via a Medline cross-search of pertinent key words. Further published studies as well as unpublished master's theses were then located from bibliographies and from cited references of articles already found. Recent issues of relevant journals were also hand-searched for applicable studies. In some instances, authors were reached by mail or telephone for access to mean or primary data.

Coding study features

The 1,233 subjects drawn from 26 studies were initially separated according to Angle classification and extraction or nonextraction treatment. In this way, each patient was used in the "Total patients" pool and also separated, when applicable, into one or more of the following specified subgroups: Class I, Class II, Class II Division 1, Class II Division 2, Nonextraction, Extraction, Class I nonextraction, Class I extraction, Class II nonextraction, Class II extraction, Class II Division 1 nonextraction, Class II Division 1 extraction, Class II Division 2 nonextraction, and Class II Division 2 extraction. All the studies and the samples used in this analysis, along with the corresponding intercanine width data, are listed in Table 1.

Quantifying study outcomes

Because of variations in the length of long-term follow-up in the 26 studies and the dearth of very long-term follow-up reports, it was deemed unfeasible to account for the time factor between T2 and T3. Therefore all intercanine measurements were treated as simply before treatment (T1), immediately posttreatment (T2), or long-term (T3). Weighted mean changes from T1 to T2 of each classification were summed together and divided by the total number of patients in that category. To obtain inferential statistical analysis of T1 to T3 intercanine difference, all data were analyzed together, then partitioned into the various orthodontic classification groups. The weighted average of the mean for each group was computed using the summary data reported in each study. The estimate for standard deviation was computed from the studies that listed data or sample standard deviations (or sample variances). The appropriate sums of squares were computed from these standard deviations and reapplied with the mean of the data-reporting group to compute a new estimate of the standard deviation for the group. The standard error of the mean was then estimated as $s.d./\sqrt{N}$, where N is the total sample size used in the standard deviation estimate.

Data analysis

T1 to T3 mean intercanine differences and their standard deviations were calculated for each orthodontic group, and 95% confidence intervals were computed. *P*-values were determined for the two-tailed *t*-test of Ho: T1-T3 = 0. The *a priori* level of significance was set at $\alpha \leq 0.05$.

Results

Table 2 shows the mean treatment changes and standard deviation in millimeters between T1 and T2, T2 and T3, and the net change between T1 and T3 for various orthodontic patient groups. Also shown for T1 to T3 are the degrees of freedom for each group, 95% confidence values, *P*-values, and summaries of the absolute number of samples in each group with either a net positive change (+), no change (0), or a net negative change (-). The weighted average T1 to T3 mentioned above combines the patient results from all these studies.

The mean intercanine treatment expansion (T1 to T2) ranged from 0.81 mm in the Class II Division 1 nonextraction patients to 2.02 mm in the Class II Division 2 nonextraction patients. Postretention constriction of this dimension (T2 to T3) ranged from 1 mm in Class II Division 2 extraction patients to 1.6 mm in both Class I nonextraction and Class II Division 2 nonextraction patients. Net changes (T1 to T3) revealed significant changes within a number of orthodontic groups, with the greatest net expansion in Class II Division 2 extraction patients, and the greatest net constriction in Class II Division 1 nonextraction patients. Because of the low number of Class II Division 2 nonextraction samples (2), statistical analysis could not be performed for T1 to T3 changes for this group.

Standard deviation, a measure of dispersion in the data, was remarkably consistent for all groups and ranged from 1.42 mm for Class II Division 1 nonextraction patients to 2.79 mm for Class I nonextraction patients. This indicates uniformity of measuring techniques and measurement results in the studies considered in the meta-analysis.

Discussion

Meta-analysis can be defined as "the application of statistical procedures to collections of empirical findings from individual studies for the purpose of integrating, synthesizing, and making sense of them."[52] One strength of meta-analysis over a traditional narrative review is that it serves to add more statistical weight to various studies by virtue of their perceived quality or scientific contribution. When considering the qualitative credentials of studies regarding postretention stability, results based on a larger number of subjects have greater likelihood of representing the population as a whole. Thus, each study received merit based on the size of the subject pool evaluated.

The range of postretention time periods for studies incorporated in this analysis was from 4 months to 12 years. While it is desirable to weight the T1 to T3 results to determine the rate of retention relapse, we were unable to do this because of the varying integrity of data.

An important point regarding the results of this study is that inferential statistics were calculated using an average weighted mean and standard deviation. Of the 26 papers used in this analysis, nearly half (12) failed to report standard deviations with their mean changes in intercanine width. Individual studies showed variation in the direction of change, but these differences were subsumed in our weighted measurement summary.

Inferential statistics are designed to determine if apparent clinically important differences in data are statistically significant. While we identified statistical differences in a number of orthodontic groups between T1 and T3, this was essentially because our sample size was large and comprised small differences. The clinical importance of a 1 or 2 mm increase in intercanine width is still debatable.

All groups, regardless of treatment modality or pretreatment malocclusion, experienced some degree of expansion of mandibular intercanine width during treatment and some constriction during the postretention period.

The range of clinical expansion was from 0.81 mm in Class II Division 1 nonextraction patients to 2.02 mm in Class II Division 2 nonextraction patients. However, the Class II Division 2 sample was relatively small, and a mean based on that data alone cannot be assumed to represent the population of these patients in a definitive way.

All means, regardless of pretreatment status or treatment modality, evidenced constriction of the intercanine dimension on the order of 1.2 to 1.9 mm. Success or failure of an orthodontic case is often interpreted in the form of posttreatment stability.[1,44] The net changes of the orthodontic treatment documented in the 26 studies here ranged from 0.46 mm of mean retained expansion to 0.59 mm of intercanine construction. The range was thus on the order of a 1 mm (-1.05) difference.

While these mean changes are useful in describing trends in therapy, they should not be used to assume changes in individual cases. As evidenced by the summary of samples presenting with positive, negative, or zero net changes between T1 and T3, not all studies demonstrated the changes that would be predicted by considering the mean net change only. In fact, on an individual basis, some cases that were enlarged in treatment will further enlarge postretention. Similarly, some cases that were not constricted during treatment will constrict postretention. Some may even constrict beyond the pretreatment dimension.

The results of this study concur with previous studies that suggest extraction procedures in orthodontically treated cases have no greater likelihood for long-term stability of changes in mandibular intercanine width than nonextraction therapy.[15,47] Furthermore, no pretreatment classification can be logically connected with more successful treatment expansion of the same dimension.

Conclusions

Through the process of meta-analysis, 26 published papers and unpublished master's theses that deal with postretention mandibular intercanine width changes have been compiled. The combined sample comprised 1,233 individual subjects who were divided into subgroups based on pretreatment classification and extraction or nonextraction treatment.

The following conclusions can be made from the data presented in this investigation:

1. Mandibular intercanine width tends to expand during treatment by 0.8 to 2.0 mm, regardless of pretreatment classification or whether treatment was extraction or nonextraction.

2. Mandibular intercanine width tends to constrict postretention by 1.2 to 1.9 mm, regardless of pretreatment classification or whether treatment was extraction or nonextraction.

3. Mandibular intercanine width tends to show a net change in postretention on the order of from 0.5 mm expansion to 0.6 mm constriction, regardless of pretreatment classification or whether treatment was extraction or nonextraction.

4. Since the net change in mandibular intercanine width was found to be approximately zero in a total of 1,233 subjects, this study clearly supports the concept of maintenance of original intercanine width in orthodontic treatment.

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