A STUDY OF RATE OF SPACE CLOSURE USING ALASTIKS AND HICE LOOPS

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TABLE OF CONTENTS

PAGE

INTRODUCTION

A biologic force applied to a tooth will cause that tooth to move and has been a well known fact for centuries. Orthodontists in this century have been seeking answers to many questions regarding force systems in tooth movement. One of the central questions investigated concerns whether there exists an optimum force for individual tooth movement. Storey and Smith conducted an investigation which has been widely interpreted as initiating concepts of optimum force.[1] The Begg treatment approach appears to be based on this concept of an optimum force resulting in differential tooth movement.[2]

Subsequent investigations by Hixon and co-workers have failed to substantiate the findings of Storey and Smith, and their experimental evidence appears to indicate a trend toward an increase in tooth movement rate with an increase in the magnitude of applied force.[3,4] Attempts to determine the actual force acting on a given unit area of root surface, as opposed to applied force, have been frustrated thus far by such problems as inaccuracy in estimating root surface area, inaccuracy in evaluating frictional resistance of the appliance, and inability to determine whether tooth movement is tipping or translatory in nature.

Experimentation by Tacy on a limited number of patients has given rates of space closure with known applied forces.[5] Subsequent work by Varner has demonstrated in vitro applied forces for Ālastik modules and Hice loops.[6]

The purpose of this investigation is to measure the rate of space closure in a relatively large sample using forces exerted by Ālastik modules and Hice loops.

REVIEW OF LITERATURE

Reports of documented studies dealing directly with the rate of tooth movement or the rate of space closure are relatively few in the orthodontic literature. In 1904, Sandstedt stated that excess pressure slowed tooth movement after he studied the effects of force on dog incisors histologically.[7] He made no reference to rate of tooth movement.

As a result of continuing investigations into the histology of tooth movement, Oppenheim concluded in a series of reports that excessive force caused thrombosis in the periodontal membrane which in turn interfered with tooth movement.[8,9,10] Like Sandstedt before him, Oppenheim did not report on force magnitude or rate of tooth movement. In a later paper he continued to report that light forces with frequent rest periods were needed for "physiologic tooth movement."[11]

In 1932, Schwarz reported on experiments with dogs and concluded that "the most favorable treatment is that which works with forces not greater than the pressure in the blood capillaries."[12] He advocated a force of about 20 to 26 grams per square centimeter of root surface. Schwarz did not comment on rate of tooth movement.

Stuteville reported on studies in dog and human subjects with forces from .5 to 200 grams which were active over distances of .2 to 2.5 mm.[13] The tooth movement he reported ranged from .8 to 1.1 mm. over time periods of 21 to 82 days. His conclusion was that the distance over which the force was active was more important than the magnitude of the force itself.

Skillen and Reitan investigated orthodontically rotated teeth in dogs and concluded that total time of force application was a more important factor than the amount of force applied for tooth movement.[14]

The first direct investigation of force related to rate of tooth movement reported in the literature seems to be that of Storey and Smith in 1952.[1] They reported on the application of measured forces to retract cuspids using molars and second premolars as anchor teeth in five patients. They used light (175-300 grams) and heavy (400-600 grams) forces. They found that with light forces the cuspid moved rapidly distally until the force was reduced to 135-180 grams, at which time movement stopped or continued at a very slow rate. The maximum rate of cuspid movement averaged about .75 mm. per week.

They also found that heavy forces caused the posterior teeth to move forward until the force decreased into the light range, at which time the cuspid began moving and the anchor teeth stopped their forward movement. In their graph of tooth movement, they showed a sub-threshold force which failed to move the cuspid, a threshold force sufficient to start movement, an optimum force at which maximum rate of movement occured, and a maximum force at which rate of movement decreased.

Reitan has reported extensively on tooth movement material from dogs and humans as studied histologically. He reported an initial period of tooth movement due to compression of the periodontal ligament that lasted from four to seven days.[15] This was followed by a period of hyalinization during which no movement took place. This period lasted from four or five days up to two months or more in some experimental animals. Following hyalinization, direct resorption occurred and the tooth continued to move.

Burstone described three phases of tooth movement with a constant force.[16] He described an initial phase of rapid tooth movement which he contributed to compression of the periodontal ligament, a lag phase of little if any tooth movement, and a post-lag phase of tooth movement. He observed that over a long time period, heavy continuous forces would move teeth at a faster rate than would lighter forces.

Burstone also reported on a study of 22 patients in whom he retracted upper anterior teeth by tipping during a 27-day period.[17] Tooth movement ranged from 0 to 3.3 mm. and tipping was optimal at forces in the 50 to 75 gram range.

Andreason and Johnson used eccentric headgear in 16 patients to apply 400 grams of force to one side and 200 grams of force to the other.[18] During the 12-week period of the investigation, the molars with 400 grams of force applied moved approximately two and one-half times further than those with 200 grams of applied force.

Weinstein reported that a two-gram force acting for eight weeks would move a tooth .8 mm.[19]

Utley studied tipping of cuspids in cats using light (50 grams), medium (150 grams), and heavy (530 grams) forces.[20] He reported great variability in response to similar forces between subjects. He was unable to relate rate of tooth movement to magnitude of force.

MacDonald investigated forces ranging from 0 to 1500 grams in eight patients for cuspid retraction.[21] With relatively constant force of about 300 grams on one side, he reported rates of space closure of .158 to .462 mm. per week in the maxilla, and .257 to .566 mm. per week in the mandible. On the other side with varying forces applied, the rate of closure increased with increased force, and the maximum was .623 mm. per week in the mandible and .486 mm. per week in the maxilla with about 1500 grams of applied force. He reported wide inter-patient variability to similar force, and within-patient increases in space closure with increased force.

Arango found no direct relationship between force and cuspid movement; however, he did report a moderate tendency for increased cuspid movement with increased force.[22] He also found that maxillary teeth showed a higher rate of cuspid movement.

Aasen also investigated rate of tooth movement as related to force and found a great individual variation in response to applied force.[23]

In 1970, Crabb and Wilson determined mean rates of tooth movement over a 28-day period with applied forces of 0.3 Newtons, 0.4 Newtons, and 0.5 Newtons.[24] They found the mean movements to be 1.0 mm., 1.1 mm., and 1.2 mm. for the three respective forces applied with removable appliances.

Sleichter evaluated light and heavy forces in clinical space closure.[25] Light forces (150 to 200 grams) closed an average of 1.0 mm. over the first four weeks with a subsequent closure of .4 mm. per week on the average. Heavy forces (1200 to 1500 grams) closed an average of 1.8 mm. over the first four weeks with a subsequent closure of .5 mm. per week on the average.

In 1972, Grimm investigated the effect of forces ranging from 500 grams to 1500 grams in tipping tooth movement.[26] He found that tooth movement varied markedly in the same force range. He also found that alveolar deformation or bone bending accounted for from .6% to 25%

of the total movement.

MATERIALS AND METHODS

The sample consisted of 26 patients from the graduate orthodontic clinic at the University of Oregon School of Dentistry. These patients were premolar extraction cases and had completed the initial leveling and bracket engagement phases of treatment. All patients except patient No. 1 had all teeth banded except third molars and maxillary second molars. Patient No. 1 had bands on the maxillary arch only, again not including second or third molars. The appliance used in each case was a .022-inch by .028-inch edgewise with Siamese brackets.

The patients ranged in age from 10 years, five months to 19 years, five months; some were just beginning active space closure and others had space closing mechanics begun prior to the start of the present study. All patients had either .019-inch by .025-inch or .021-inch by .025-inch archwires, and closing forces were applied with either the Kx series of $\bar{A}$lastiK modules or with Hice loops. Each patient was asked to wear Kloehn headgear 12 to 14 hours per day.

In each patient, a mark was placed on the archwire immediately distal to the canines in each quadrant. The mark was placed with a sharp ligature cutter in a position where it would be visible with the archwire ligated to place. Each time the patient had an appointment, the graduate student treating that patient would measure the distance from the mesial of the bracket or tube on the first molar to the mark on the wire in each quadrant. If the archwire was removed on that appointment, a second set of measurements were taken after the archwire had been replaced.

All measurements were taken with a pair of needle-point dividers and punched on a five by eight-inch index card attached to the front of the patient's chart. A total of five examiners were involved in transferring these measured distances from patients to index cards.

The actual determination of the lengths of these measurements was done by the author using a Bull caliper, accurate to 0.1 mm., from the index cards with the holes punched by the needle-point dividers.

In order to evaluate the measurement error of this technique, each of the five examiners made replicate measurements on two patients and recorded these on the index cards with the needle-point dividers.

These measurements were made at least ten minutes apart and totaled eight repeated measurements. The author made replicate measures on 30 of the marked distances on the index cards with the Bull caliper to determine measurement error.

At the conclusion of the collection of the data for this report, the decision was made to record all of the data as case reports so the information would be available for future refinement of the technique and further investigation. These individual sets of data are included as an appendix to this paper. No statistical treatment of this raw data has been undertaken in this present report.

DISCUSSION

Previous studies on rate of space closure have used a relatively small sample size and frequently employed several different force magnitudes. The resulting data on rate of tooth movement has thus been based on an inadequate sample size for each magnitude of force applied.

The present study was undertaken in an attempt to get information on rate of space closure from a more adequate sample size with an approximately known applied force. Varner found that forces from ĀlastiK modules of the Kx type applied forces ranging from .86 to 1.4 pounds after 24 hours, and .82 to 1.2 pounds after four weeks.[6] He also found that Hice loops averaged 1.7 pounds of applied force.

After collecting the data on the 26 patients used in this study, it became apparent that extensive statistical treatment of this data would be of questionable value. Data on some of the patients was very limited, and the measurement error for some of the replicate measures as found in Table I were quite large. Therefore, the decision was made to report all of the raw data as case reports without statistical evaluation.

After reviewing the information contained in this report, some general statements can be made. The most apparent conclusion one arrives at is that there is wide variability in rate of space closure to similar magnitudes of applied force. This wide variability is manifest not only between patients but also in the same patient during different measurement periods. Even recognizing possible mechanical explanations for this variability such as occlusal interferences, binding of the appliance, and differences in time wearing headgear, one must recognize wide ranges of individual variation.

Additional impressions conveyed by this data are that maxillary spaces tend to close more rapidly and that rate of closure tends to increase with increased force applied using the edgewise appliance of the type used in the present study.

The basic format for this investigation seems to be sound. Some modifications of the procedure for collecting the data could probably enhance the value of the study. The following changes in technique would probably be beneficial.

1) One investigator should take all measurements. Measurement error could probably be reduced in this manner.

2) Standardize the time that the measurements are taken. It is possible that misleading rates of closure could be obtained if measurements were not consistently taken either before or after ĀlastiK removal or replacement. Probably the best procedure would be to measure with the old ĀlastiK still in place and then again after the new ĀlastiK is applied if the archwire has been removed.

3) Close all anterior spaces prior to the study and make all measurements to the bracket of the canine or to a mark on the canine band. This procedure would eliminate the possibility of the archwire slipping through the brackets and contributing to an apparent differential rate of closure between the right and left sides.

4) Maintain close control of time elapsed between appointments. This would help to standardize force applications and could easily be done if one investigator were taking all measurements.

5) Group patients according to type of malocclusion.

6) Follow each patient from the first time closing mechanics are activated. This would give better information regarding within-patient variability. The drawback to this suggestion in terms of a graduate student project is that total research time would be extended.

The idea of recording measurements on cards and measuring with a Bull caliper seems to be a good one as demonstrated by the consistently low measurement error in Table II.

SUMMARY AND CONCLUSIONS

The rate of space closure was determined in 26 patients using Ālastik modules or Hice loops to apply closing forces. The patients were followed for approximately three months and measurements were taken during their routine scheduled orthodontic appointments at intervals of approximately three to six weeks. All of the data collected for this report is included in Appendix A.

Based on this investigation, the following conclusions can be made:

1) There is great inter-patient and intra-patient variation in rate of space closure when a similar magnitude of closing force is applied.

2) There may be tendency for space to close more rapidly in the maxilla than in the mandible.

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Table I Measurement Error

Operator	Patient	Quadrant	1^{st} Measure	2^{nd} Measure	Difference
1	A	UR	14.1	13.9	.2
1	A	UL	16.1	16.1	.0
1	A	LR	17.3	17.3	.0
1	A	LL	17.4	17.4	.0
2	A	UR	13.8	14.0	.2
2	A	UL	16.3	16.3	.0
2	A	LR	17.6	17.6	.0
2	A	LL	17.5	17.4	.1
3	A	UR	12.9	13.7	.8
3	A	UL	15.7	15.7	.0
3	A	LR	17.2	16.8	.4
3	A	LL	17.0	17.1	.1
4	A	UR	13.8	14.0	.2
4	A	UL	16.2	16.2	.0
4	A	LR	17.4	17.6	.2
4	A	LL	17.4	17.6	.2
5	A	UR	14.0	14.2	.2
5	A	UL	16.1	16.2	.1
5	A	LR	17.3	17.1	.2
5	A	LL	17.2	17.5	.3
1	B	UR	12.3	12.4	.1
1	B	UL	14.0	14.0	.0
1	B	LR	11.7	12.3	.6
1	B	LL	12.3	12.3	.0
2	B	UR	12.2	12.5	.3
2	B	UL	13.8	13.8	.0
2	B	LR	12.1	11.9	.2
2	B	LL	12.1	12.4	.3
3	B	UR	12.2	12.2	.0
3	B	UL	14.1	13.7	.4
3	B	LR	11.6	11.8	.2
3	B	LL	12.0	12.1	.1
4	B	UR	12.2	12.1	.1
4	B	UL	13.7	13.5	.2
4	B	LR	12.1	11.6	.5
4	B	LL	12.4	12.6	.2
5	B	UR	11.9	12.1	.2
5	B	UL	14.1	13.7	.4
5	B	LR	11.6	12.0	.4
5	B	LL	12.2	12.5	.3

Mean difference .19
Range of differences .0 - .8
SEMeas (excluding differences above .4) ~~.28~~ .257

Table II Measurement Error (3" x 5" cards)

Patient	Date	Quadrant	1st Measure	2nd Measure	Difference
1	11-01-74	UR	13.7	13.8	.1
1	01-10-75	UL	12.7	12.8	.1
2	01-03-75	UL	13.7	13.7	.0
2	03-07-75	LR	11.6	11.7	.1
3	01-20-75	UR	9.8	9.9	.1
3	01-20-75	LL	13.3	13.2	.1
4	11-14-74	UL	12.4	12.4	.0
4	01-15-75	LL	10.4	10.4	.0
5	12-05-74	LR	13.3	13.3	.0
5	02-20-75	UL	10.4	10.5	.1
6	01-03-75	LL	17.3	17.4	.1
6	02-14-75	LR	16.2	16.4	.2
7	11-18-74	LL	16.1	16.2	.1
8	01-06-75	UR	17.8	18.0	.2
8	03-03-75	UL	17.5	17.5	.0
9	11-18-74	UR	16.3	16.4	.1
9	02-24-75	UL	13.4	13.5	.1
10	12-02-74	LR	14.0	13.9	.1
11	11-21-74	LR	11.3	11.2	.1
12	01-30-75	LR	8.4	8.6	.2
13	12-19-74	UL	18.0	18.1	.1
14	01-06-75	LL	9.3	9.3	.0
15	01-03-75	UR	13.1	13.0	.1
16	12-10-74	LL	11.9	12.0	.1
17	02-21-75	LR	12.7	12.8	.1
18	11-26-74	LL	12.9	13.0	.1
19	12-06-74	LR	4.3	4.5	.2
20	11-25-74	LR	15.7	15.8	.1
20	03-14-75	LL	14.0	14.1	.1
21	01-13-75	LR	11.7	11.7	.0

Mean difference .09

Range of differences .0 - .2

SEMeas ~~.21~~ .076

APPENDIX A

Patient No. 1

Arch size - .021" x .025"

Operator No. 1

Type of Closure - ĀlastiK

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-01-74		UR	13.7				
		UL	15.6				
		LR					
		LL					
11-21-74	20	UR	13.7		.0	.0	.0
		UL	16.7		+1.1	+ .39	+1.1
		LR					
		LL					
12-13-74	22	UR	12.9		- .8	- .25	- .8
		UL	15.0		-1.7	- .54	- .6
		LR					
		LL					
01-10-75	28	UR	11.6	11.2	-1.3	- .32	-2.1
		UL	12.7	12.7	-2.3	- .57	-2.9
		LR					
		LL					
01-31-75	21	UR	10.9		- .3	- .10	-2.4
		UL	11.1		-1.6	- .53	-4.5

Patient No.2

Arch size - .021" x .025"

Operator No. 1

Type of Closure - ĀlastiK

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
12-06-74		UR	13.9				
		UL	15.0				
		LR					
		LL					
01-03-75	28	UR	12.8		1.1	.27	1.1
		UL	13.7		1.3	.32	1.3
		LR					
		LL					
01-24-75	21	UR	12.5		.3		1.4
		UL	14.6		+ .9		.4
		LR	12.1				
		LL	12.5				
02-14-75	21	UR	12.4		.1	.34	1.5
		UL	13.7		.9	.30	1.3
		LR	11.8		.3	.10	.3
		LL	12.3		.2	.07	.2
03-07-75	21	UR	11.0	11.8	1.4	.47	2.9
		UL	13.3	12.2	.4	.13	1.7
		LR	11.6	12.4	.2	.07	.5
		LL	11.6	10.9	.7	.23	.9
03-28-75	21	UR	11.5		.3	.10	3.2
		UL	11.6		.6	.20	2.3
		LR	11.7		.7	.23	1.2
		LL	10.7		.2	.07	1.1

Patient No. 3

Arch size - .019" x .025"

Operator No. 1

Type of Closure - ĀlastiK

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
12-12-74		UR	11.6				
		UL	13.7				
		LR	14.8				
		LL	14.3				
01-20-75	39	UR	9.8		1.8	.32	1.8
		UL	11.8		1.9	.34	1.9
		LR	13.3		1.5	.27	1.5
		LL	13.3		1.0	.18	1.0
02-14-75	25	UR					
		UL					
		LR	12.7		.6	.17	2.1
		LL	11.7		1.6	.45	2.6

Patient No. 4

Arch size - .019" x .025"

Operator No. 1

Type of Closure - ĀlastiK

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-14-74		UR	14.1				
		UL	12.4				
		LR	24.6				
		LL	25.3				
12-12-74	28	UR	12.9	13.7	1.2	.30	1.2
		UL	11.3	12.3	1.1	.27	1.1
		LR	24.0	23.6	.6	.15	.6
		LL	22.6	22.0	2.7	.67	2.7
01-15-75	34	UR	13.4		.3	.06	1.5
		UL	12.0		.3	.06	1.4
		LR					
		LL					

Patient No. 5

Arch size - .019" x .025"

Operator No. 1

Type of Closure - Alastik

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-07-74		UR	14.3				
		UL	14.7				
		LR	14.2				
		LL	12.8				
12-05-74	28	UR	13.7	13.7	1.4	.35	1.4
		UL	13.3	14.2	1.4	.35	1.4
		LR	13.3	12.9	.9	.22	.9
		LL	11.5	11.8	1.3	.32	1.3
01-23-75	49	UR	10.2		3.5	.50	4.9
		UL	11.1		3.1	.44	4.5
		LR	11.4		1.5	.22	2.4
		LL	10.5		1.3	.19	2.6
02-20-75	28	UR	9.1		1.1	.27	6.0
		UL	10.4		.7		5.2
		LR					
		LL					

Patient No. 6

Arch size - .019" x .025"

Operator No. 3

Type of Closure - Ālastik

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
12-06-74		UR					
		UL					
		LR	16.7				
		LL	17.6				
01-03-75	28	UR					
		UL					
		LR	15.6		1.1	.27	1.1
		LL	17.3		.3	.08	.3
01-24-75	21	UR					
		UL					
		LR	15.1		.5	.17	1.6
		LL	16.4		.9	.30	1.2
02-14-75	21	UR					
		UL					
		LR	16.2		+ 1.1	+ .36	
		LL	16.2		.2	.07	1.4
03-07-75	21	UR					
		UL					
		LR					
		LL					

Patient No. 7

Arch size - UA .019" x .025"
LA .021" x .025"

Operator No. 3

Type of Closure - Hice loop

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-18-74		UR					
		UL					
		LR					
		LL	16.1				
12-11-74	23	UR					
		UL					
		LR					
		LL	17.8		+1.7	+ .52	+1.7
01-13-75	33	UR					
		LL					
		LR					
		LL	16.6		1.2	.25	+ .5
02-10-75	28	UR					
		UL					
		LR					
		LL	15.4		1.2	.30	.7
03-03-75	21	UR					
		UL					
		LR					
		LL	14.7		.7	.23	.14
03-14-75	11	UR					
		UL					
		LR					
		LL	14.0		.7	.45	.21

Patient No. 8

Arch size - .021" x .025"

Operator No. 3

Type of Closure - Hice loops

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-18-74		UR	22.0				
		UL	25.8				
		LR					
		LL					
12-09-74	21	UR	(Hice loops tightened; forgot to measure.)				
		UL					
		LR					
		LL					
01-06-75	28	UR	17.8		4.2	.60	4.2
		UL	19.6		6.2	.92	6.2
		LR					
		LL					
01-27-75	21	UR	17.2		.6	.20	4.8
		UL	18.8		.8	.27	7.0
		LR					
		LL					
03-03-75	35	UR	16.8		.4	.08	5.2
		UL	17.5		1.3	.20	8.3
		LR					
		LL					

Patient No. 9

Arch size - .021" x .025"

Operator No. 3

Type of Closure - Hice loops

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-18-74		UR	16.3				
		UL	16.1				
		LR					
		LL					
12-09-74	21	UR	15.9		.4	.13	.4
		UL	16.0		.1	.034	.1
		LR					
		LL					
01-06-75	28	UR	15.1		.8	.20	1.2
		UL	15.6		.4	.098	.5
		LR					
		LL					
01-27-75	21	UR	15.2		+ .1	+ .034	1.1
		UL	15.7		+ .1	+ .034	.4
		LR					
		LL					
02-24-75	28	UR	15.2		.0	.0	1.1
		UL	13.4		2.3	.57	2.7
		LR					
		LL					

Patient No. 10

Arch size - .019" x .025"

Operator No. 3

Type of Closure - Ālastik

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	closure
10-28-74		UR	16.5				
		UL					
		LR					
		LL					
11-08-74	11	UR	15.9		.6	.39	.6
		UL	15.5				
		LR	16.6				
		LL	15.6				
12-02-74	24	UR	15.3		.6	.18	1.2
		UL	14.6		.9	.27	.9
		LR	14.0		2.8	.84	2.8
		LL	15.2		.4	.12	.4
01-06-75	35	UR	14.1		1.2	.24	2.4
		UL	14.4		.2	.040	1.1
		LR	14.5		+ .5	+ .098	2.3
		LL	14.6		.6	.12	1.0

Patient No. 11

Arch size - .021" x .025"

Operator No. 5

Type of Closure - ĀlastiK

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
10-31-74		UR	14.8				
		UL	15.1				
		LR	13.7				
		LL	14.7				
11-21-74	21	UR	12.3		2.5	.84	2.5
		UL	14.3		1.2	.40	1.2
		LR	11.3		2.4	.77	2.4
		LL	14.4		.3	.098	.3
01-09-75	18	UR	12.5		+ .2	.077	2.3
		UL	11.7		2.6	.98	3.8
		LR	11.2		.1	.039	2.5
		LL	13.4		1.0	.39	1.3
02-20-75	42	UR	12.0	12.5	.5	.084	2.8
		UL	11.4	11.2	.3	.049	4.1
		LR	8.5	7.7	2.7	.45	5.2
		LL	13.0	12.2	.4	.067	1.7
03-26-75	34	UR	11.6		.9	.18	3.7
		UL	10.6		.6	.13	4.7
		LR					
		LL					

Patient No. 12

Arch size - .021" x .025"

Operator No. 5

Type of Closure - Ālastik

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
10-24-74		UR	9.6				
		UL	17.3				
		LR	10.8				
		LL	11.2				
12-05-74	42	UR	8.6		1.0	.17	1.0
		UL	8.3	(error)			
		LR	8.9		1.9	.32	1.9
		LL	11.5		+ .3	+ .049	+ .3
01-08-75	34	UR	8.2		.4	.084	1.4
		UL	13.2		+4.9	+ .98	
		LR	10.0		1.1	.22	3.0
		LL	10.1		1.4	.29	1.1
01-30-75	22	UR	15.6	(error)	+7.4	+2.4	
		UL	11.8		1.4	.45	
		LR	8.4		1.6	.51	
		LL	11.3		+1.2	+ .39	
02-20-75	21	UR	15.3		.3	.098	
		UL	11.4		.4	.13	
		LR					
		LL					

Patient No. 13

Arch size - .021" x .025"

Operator No. 5

Type of Closure - ĀlastiK

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-19-74		UR	12.4				
		UL	19.2				
		LR	12.1				
		LL	11.8				
12-09-74	20	UR	10.1		2.3	.84	2.3
		UL	18.0		1.2	.42	1.2
		LR	11.6		.5	.18	.5
		LL	11.5		.3	.11	.3
01-14-75	36	UR	12.6		+2.5	+ .48	+ .2
		UL	16.6		1.4	.27	2.6
		LR	11.2		.4	.077	.9
		LL	11.7		+ .2	+ .039	.1

Patient No. 14

Arch size - .021" x .025"

Operator No. 5

Type of closure - Hice loops

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
10-28-74		UR					
		UL					
		LR	10.7				
		LL	12.2				
12-02-74	35	UR					
		UL					
		LR	9.5		1.2	.24	1.2
		LL	11.1		1.1	.22	1.1
01-06-75	35	UR					
		UL					
		LR	8.9		.6	.12	1.8
		LL	9.3		1.8	.36	2.9

Patient No. 15

Arch size - LA .019" x .025"
UA .021" x .025"

Operator No. 4

Type of Closure - Hice Loops

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-14-74		UR					
		UL					
		LR	11.0				
		LL	14.2				
12-09-74	25	UR	14.6				
		UL	14.4				
		LR	10.9	10.9	.1	.028	.1
		LL	14.4	14.2	+ .2	+ .056	+ .2
11-03-75	25	UR	13.1		1.5	.42	1.5
		UL	12.9		1.5	.42	1.5
		LR	10.2		.7	.20	.8
		LL	13.3		.9	.25	.7
01-13-75	10	UR	12.5	12.0	.6	.42	2.1
		UL	14.7	12.9	.2	.14	1.7
		LR	10.2		.0	.0	.8
		LL	13.4		+ .1	+ .07	.6
02-13-75	31	UR	10.6		1.4	.32	3.5
		UL	12.9		.0	.0	1.7
		LR	9.8		.4	.091	1.2
		LL	12.4	11.9	1.0	.22	1.6
03-03-75	18	UR	8.9		1.7	.66	5.2
		UL	11.7		1.2	.47	2.9
		LR					
		LL	11.1		.8	.39	2.4
03-24-75	21	UR	7.9		1.0	.34	6.2
		UL	12.4		+ .7	+ .23	2.2
		LR					
		LL					

Patient No. 16

Arch size - .021" x .025"

Operator No. 4

Closure - Alastik

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-19-74		UR					
		UL					
		LR	13.2				
		LL	12.9				
12-10-74	21	UR					
		UL					
		LR	12.5		.7	.23	.7
		LL	11.9		1.0	.34	1.0
01-13-75	34	UR					
		UL					
		LR	12.2		.3	.062	1.0
		LL	11.8		.1	.020	1.1

Patient No. 17

Arch size - .019" x .025" Operator No. 4

Type of closure - ĀlastiK

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total Closure
11-18-74		UR					
		UL					
		LR	14.7				
		LL	13.2				
12-06-74	18	UR					
		UL					
		LR	13.9	13.7	.8	.31	.8
		LL	11.7	11.0	1.5	.58	1.5
02-21-75	77	UR					
		UL					
		LR	12.7		1.0	.091	1.8
		LL	10.4		.6	.055	2.1

Patient No. 18

Arch size - .019" x .025"

Operator No. 4

Type of closure - ĀlastiK

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-05-74		UR					
		UL					
		LR	13.8				
		LL	12.9				
11-26-74	21	UR					
		UL					
		LR	13.1		.7	.23	.7
		LL	12.9		.0	.0	.0
12-10-74	14	UR					
		UL					
		LR	11.7		1.4	.70	2.1
		LL	12.0		.9	.45	.9

Patient No. 19

Arch size - .019" x .025"

Operator No. 4

Type of closure - ĀlastiK

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-08-74		UR					
		UL					
		LR	15.1				
		LL	12.8				
12-06-74	28	UR					
		UL					
		LR	14.3		.8	.20	.8
		LL	12.2		.6	.15	.6
01-10-75	35	UR					
		UL					
		LR	13.4	13.8	.9	.18	1.7
		LL	11.8	11.6	.4	.077	1.0
01-31-75	21	UR					
		UL					
		LR	13.0		.8	.27	2.5
		LL	11.2	10.9	.4	.13	1.4
02-21-75	21	UR					
		UL					
		LR					
		LL	9.7		1.2	.40	2.6
03-18-75	25	UR					
		UL					
		LR					
		LL	8.9		.8	.22	3.4

Patient No. 20

Arch size - .019" x .025"

Operator No. 1

Type of closure - Ālastik

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
10-29-74		UR					
		UL					
		LR	17.3				
		LL	16.6				
11-25-74	27	UR					
		UL					
		LR	15.7		1.6	.41	1.6
		LL	15.0		1.6	.41	1.6
12-09-74	14	UR					
		UL					
		LR	14.5		1.2	.60	2.8
		LL	13.7		1.3	.65	2.9
01-13-75	35	UR					
		UL					
		LR	12.8		1.7	.34	4.5
		LL	12.3		1.4	.28	4.3

Patient No. 21

Arch size - .019" x .025"

Operator No. 1

Type of Closure - Āastik

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total Closure
12-9-74		UR					
		UL					
		LR	13.5				
		LL	13.7				
01-13-75	35	UR					
		UL					
		LR	11.7		1.8	.36	1.8
		LL	11.8		1.9	.38	1.9

Patient No. 22

Arch size - .021" x .025"

Operator No. 1

Type of Closure - Ālastik

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Closure
02-05-75		UR	10.3				
		UL	12.4				
		LR	12.7				
		LL	13.8				
02-21-75	16	UR	10.3	11.6	.0	.0	.0
		UL	11.6	11.5	.8	.35	.8
		LR	11.8		.9	.39	.9
		LL	13.5		.3	.13	.3
03-14-75	21	UR	9.8	11.3	1.8	.60	1.8
		UL	10.1	11.0	1.4	.47	2.2
		LR	10.9		.9	.30	1.8
		LL	13.0		.5	.17	.8
04-11-75	28	UR	11.0		.3	.077	2.1
		UL	10.0		1.0	.70	3.2
		LR					
		LL					

Patient No. 23

Arch size - .021" x .025"

Operator No. 2

Type of Closure - Ālastik

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
01-10-75		UR	14.0				
		UL	14.8				
		LR					
		LL					
01-24-75	14	UR	13.9		.1	.050	.1
		UL	14.2		.6	.30	.6
		LR					
		LL					
02-28-75	35	UR	12.2	11.8	1.7	.34	1.8
		UL	12.3	13.7	1.9	.38	2.5
		LR					
		LL					
03-28-75	28	UR	11.1	11.1	.7	.18	2.5
		UL	13.3	13.3	.4	.10	2.9
		LR					
		LL					
04-11-75	14	UR	10.3		.8	.40	3.3
		UL	12.5		.8	.40	3.7
		LR					
		LL					

Patient No. 24

Arch size - .019" x .025"

Operator No. 1

Type of Closure - Hice loops

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
11-18-74		UR					
		UL					
		LR	5.1				
		LL	8.7				
12-02-74	14	UR					
		UL					
		LR	4.3		.8	.40	.8
		LL	7.5		1.2	.60	1.2
01-06-75	35	UR					
		UL					
		LR	2.8		1.5	.30	2.3
		LL	6.7		.8	.16	2.0

Patient No. 25

Arch size - .019" x .025"

Operator No. 2

Type of Closure - Ālastik

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
01-22-75		UR					
		UL					
		LR	5.0				
		LL	3.8				
02-05-75	14	UR	6.2				
		UL	5.6				
		LR	4.7		.3	.15	.3
		LL	3.8		.0	.0	.0
02-26-75	21	UR	5.6		.6	.2	.6
		UL	5.1		.5	.17	.5
		LR	4.5		.2	.067	.5
		LL	3.8		.0	.0	.0
03-25-75	27	UR	4.5	4.1	1.1	.29	1.7
		UL	3.4	3.5	1.7	.44	2.2
		LR	4.5		.0	.0	.5
		LL	3.3		.5	.13	.5
04-15-75	21	UR	3.9		.2	.067	1.9
		UL	3.7		+ .2	+ .067	2.0
		LR					
		LL					

Patient No. 26

Arch size - .021" x .025"

Operator No. ~~26~~ 4

Type of Closure - Hice loops

Date	No. days	Quadrant	Space	New 0 point	Closure	Rate mm./wk.	Total closure
10-21-74		UR	15.3				
		UL	12.3				
		LR					
		LL					
11-18-74	28	UR	13.2	12.3	2.1	.53	2.1
		UL	10.6	11.2	1.7	.43	1.7
		LR					
		LL					
12-02-74	14	UR	11.9		.4	.20	2.5
		UL	10.6		.6	.30	2.3
		LR					
		LL	7.3				
01-06-75	35	UR	9.6		2.3	.46	4.8
		UL	10.6		.0	.0	2.3
		LR					
		LL					
01-27-75	21	UR					
		UL					
		LR					
		LL	5.0	5.0	2.3	.77	2.3
02-24-75	28	UR					
		UL					
		LR					
		LL	4.2		.8	.20	3.1