Surgically assisted rapid maxillary expansion: A comparison of technique, response, and stability

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Transverse correction of the maxilla using orthopedic forces was first described in the literature more than 130 years ago.[1] Due largely to the efforts of Haas,[2-5] orthopedic maxillary expansion has now become routine.

Krebs,[6,7] and later, Wertz,[8-11] documented increased resistance to maxillary base expansion with age, and other authors have speculated about the factors that limit maxillary expansion. Isaacson and colleagues[12,13] demonstrated that many factors come into play, but that the bones and osseous structures that adjoin the maxillary bone, including the zygomaticomaxillary buttress, are among the most conspicuous. Obwegeser[14] and Steinhauser[15] suggested a surgical method of splitting the maxilla to correct malocclusions. This has been explored further by other authors.[16-21]

The complications resulting from attempts to orthopedically expand the transverse dimension in nongrowing patients has long been a troubling problem. The purpose of this investigation was to compare and contrast treatment rewards and sequelae emanating from three different approaches to maxillary expansion in nongrowing individuals, and to compare the changes with those that take place in a control group of nonexpanded, treated adults.

Materials and methods

The author has treated 43 adults using surgically assisted rapid maxillary expansion. Patients were treated using one of two similar surgical procedures. Haas has a similar sample of adults who received expansion therapy but who were treated without surgery. These cases comprise a

Abstract

The purpose of this study was to evaluate the differences in treatment effects between adult patients who underwent surgically assisted rapid maxillary expansion employing buccal corticotomies and those who had midpalatal splits as well. Responses and sequelae of these treated patients were compared with adults who were expanded orthopedically and adults who were treated orthodontically without expansion. The sample comprised 37 patients who were expanded and 5 controls. Dental study casts were taken prior to treatment, at debanding, and at the posttreatment follow-up. The results indicated that maxillary expansion in adults was predictable and stable, corrected crossbites remained corrected, palatal depth was reduced in SARME, palatal width increased (more dramatically in patients treated with a combined procedure), and tipping was controlled and stable. The long-term buccogingival condition was more acceptable in adults expanded with surgical augmentation than in those expanded orthopedically.

Key Words

Surgically assisted maxillary expansion

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Table 1
Sample summary by age, sex, and treatment duration

Group	N	M/F	Mean age (Range)	Years in treatment	Years in retention
Nonsurgically expanded patients (NS)	15	9 / 7	22.48 (15.5-39.6)	2.36	11.83
Buccal corticotomies with simple split at ANS (BC)	7	0 / 7	29.19 (16.7-38.0)	1.81	2.39
Combined surgical group (CS)	15	6 / 10	25.97 (17.0-35.3)	2.01	5.47
Orthodontically treated control group (C)	5	3 / 4	34.44 (27.3-47.1)	1.86	5.94

third treatment category. Study casts for the three groups were compared with a similarly aged control group that had received conventional orthodontic treatment with no effort to expand the maxilla. The four groups were measured, using pretreatment, immediate posttreatment (debanding after expansion plus conventional orthodontics), and follow-up dental cast records to evaluate treatment effects and stability.

This study examines treatment with tissue-borne, Haas-type appliances only. Bands were cemented onto the molars and premolars, as described by Haas,[4,5] but only two of the surgical patients received the benefit of a wire soldered on the buccal of the appliance, as Haas recommended. All the nonsurgical patients had this soft tissue reinforcement and a soldered wire on the labial.

Sample

All 43 patients who had surgically assisted palatal expansion were approached for inclusion in the study. After exclusion for reasons such as inability to return to have records updated, inability to locate, and too recently finished to provide meaningful data, the sample consisted of 22 patients. Of the original 20 nonsurgical (Haas) cases, five were removed because their records were inconsistent or they were too young, leaving a sample of 15.

Surgical procedures

In the buccal corticotomy (BC) group, incisions were made in the buccal vestibule, allowing the surgeon to cut through the cortical bone from the piriform aperture to the pterygoid fissure bilaterally. The fissure was not involved surgically. An incision was then made between the apices of the central incisors, allowing an osteotome to be passed posteriorly along the hard palate far enough back to allow confirmation that the halves of the palate could be separated.

In the combined surgery [CS] group, a palatal flap was laid in a horseshoe shape, allowing access to the midpalatine suture. A bone bur was used to cut through the bone on either side of the suture from the incisive foramen posteriorly to PNS. Two bony cuts were made to prevent septal deviation during the subsequent expansion. In both procedures care was taken to close the soft tissue to minimize the potential for problems during healing.

In the nonsurgical (NS) or Haas group, rapid maxillary expansion was provided on a slow basis; the patients were expanded up to twice per day, or as pain would allow. Some patients were expanded for as long as 1 to 2 months. No surgery was involved.

Measurement method

Transverse widths of the maxillary and mandibular molars and canines were measured. Mandibular widths were important in determining expansion needs. Initially, all measurements were made using a dial caliper, measuring to one thousandth of an inch. The measurements were subsequently repeated using a convertible CenTech millimetric/inches caliper. All findings were represented in millimeters. Buccal widths of the mandibular first molars were also measured in the buccal groove. If the first molar was not present throughout the course of treatment, the second molar was substituted from the outset. The width between mandibular mesiobuccal cusp tips was also measured in order to validate the buccal width measurement and to describe any rotations that might occur.

The width between the labial surfaces of the mandibular canines was then recorded as was the distance between the mandibular canine cusp tips. Care was taken to identify landmarks and record them using a fine-pointed pencil to maximize accuracy and reproducibility.

The following widths were measured in the maxillary arch: first molars, buccal groove, mesiolingual cusp tip, and the most labial of the canines and the canine cusp tip. Measurements were then made from the incisal edge to the depth of the labial contour on the free gingival margin in order to record the crown heights of

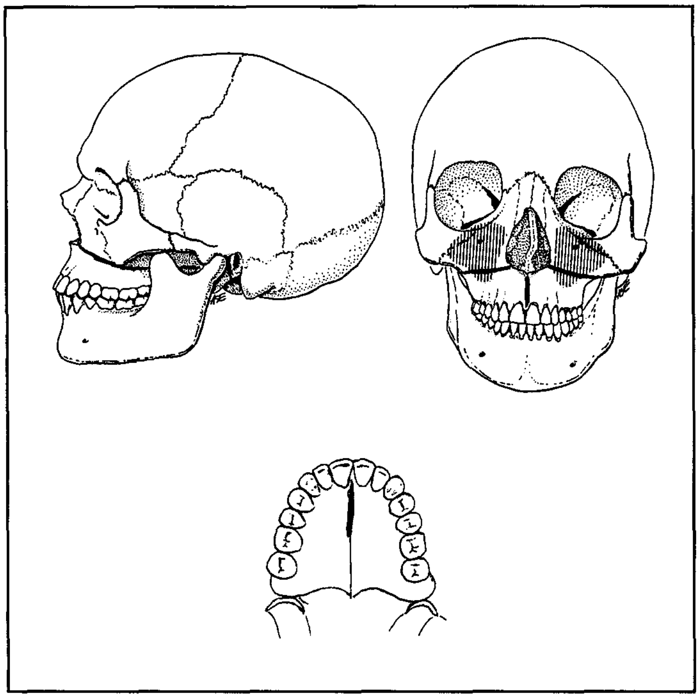

Figure 1A

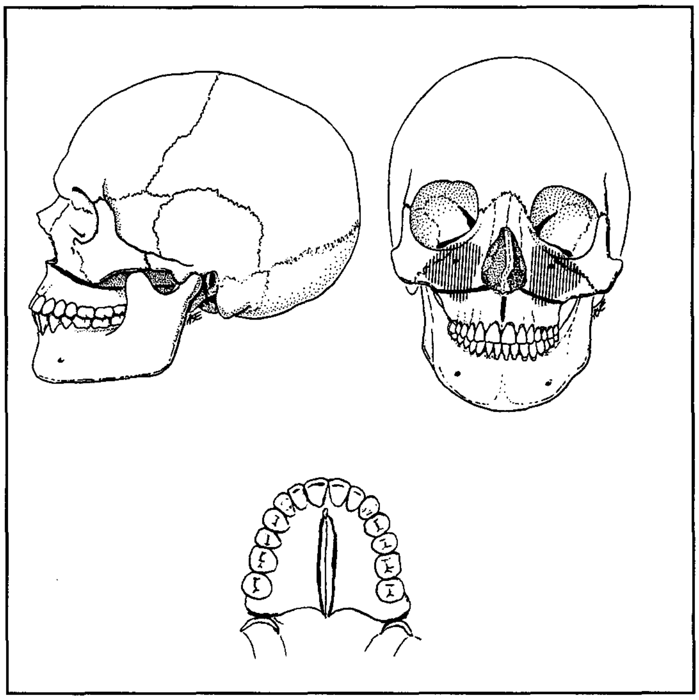

Figure 1B

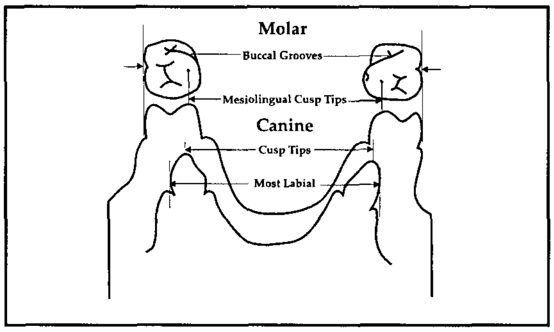

Figure 2

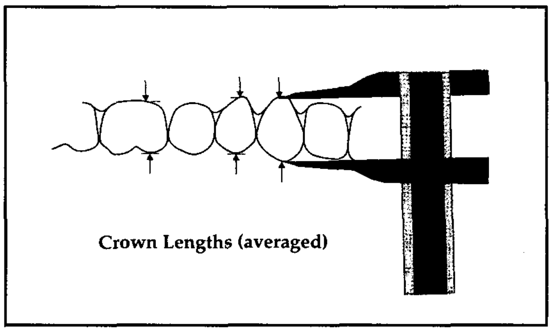

Figure 3

Figure 1A-B
Buccal corticotomy and combined surgery

Figure 2
Schematic measurements for arch width.

Figure 3
Schematic measurement for crown length

the maxillary canine, maxillary first premolar (or second if the first had been extracted), and the first molar. Tooth measurements were averaged with the crown height of the contralateral tooth in the hope of providing an index of clinical crown length.

Using a machinist's dial caliper, the depth of the palatal vault at the first molars and premolars was measured. This was done by measuring the distance between the palatal depth and a straight edge (Boley gauge) laid across the occlusal surfaces of the molars and the premolars. Similar palatal points were used by sighting on a straight line between two points on teeth on opposite sides of the arch and matching them up with palatal rugae and contours. Palatal rugae have provided valid reference points in numerous previous studies.[22,23] All measurements were made in millimeters.

In an effort to calculate the width of the palate, a height 5 mm occlusal to the palatal depth marks noted above was conveyed on the lateral aspect of the palate, on each side. The width between these scorings was measured. The arbitrary height, 5 mm occlusal to the greatest depth of the palate, was selected in an attempt to standardize the measurements.

Finally, the amount of tipping at the molar and the first premolar was measured using the dial caliper. The difference between the height of the distobuccal and distolingual cusp tips of the molar that was used in calculating the maxillary molar widths was measured. The difference between the two cusp tips was averaged with that of the contralateral tooth. This removed inconsistencies created by irregularities in model trimming.

All measurements were made by the principal author and a dental hygienist who did not know how the patients had been treated or if they were controls. Each set of models from each patient was measured in series to improve the reproduc-

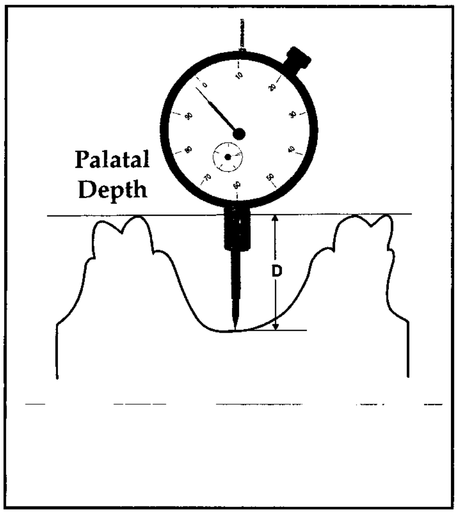

Figure 4

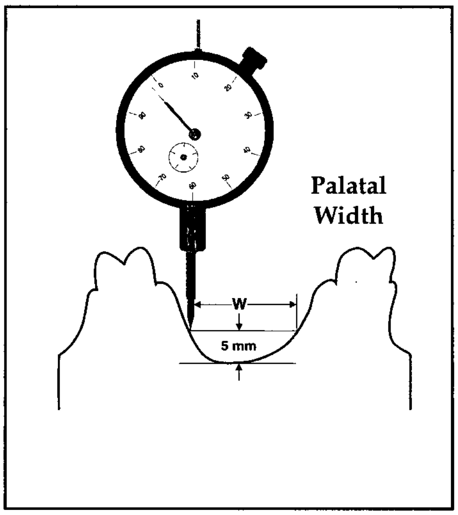

Figure 5

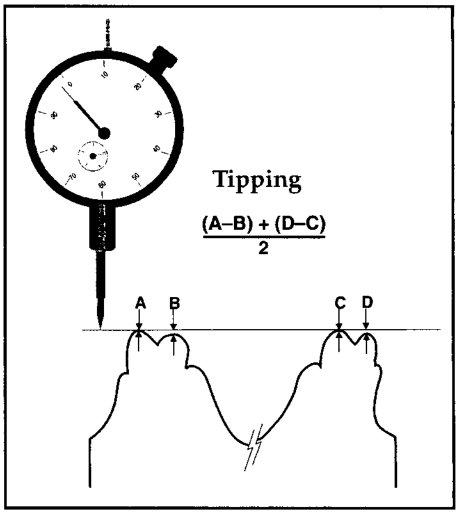

Figure 6

Figure 4
Schematic measurement for depth of palate

Figure 5
Schematic for measuring width of palate

Figure 6
Schematic for measuring tipping

ibility of identity points. The cases treated nonsurgically were known to be different by the measuring hygienist, but she was unaware of the differences we were trying to record. The author measured, at random, approximately one-third of the cases

Intraobserver and interobserver error studies were run. Twenty-three of the 42 cases studied were selected randomly to test measurement error. These cases were remeasured by the original observer, and a set of crossover measurements was made to test interobserver error. Analysis of variance has been used to evaluate differences among groups, and Scheffe comparisons have been used to determine groups that performed differently from one another. An index where P=0.05 (5%) or lower was taken to be significant, 0.01 to be highly significant, and 0.001 and beyond to be very highly significant.

Results

Measurement error

Measurement accuracy for the observers was 0.34 mm and 0.24 mm, respectively. Interobserver error was 0.31 mm.

Buccal widths at the molar: The cases treated nonsurgically presented, on average, pretreatment mandibular molar widths that were 2 to 3 mm wider than the other three groups as measured either at the buccal groove or across the mesiobuccal cusp tips. These differences were not statistically significant. In the maxillary arch, pretreatment molar widths in those cases treated nonsurgically were almost 4 mm wider than either of the surgical groups and about the same as the control (C) group. In other words, using mean data, the transverse needs of all expansion groups were about the same. See Table 2 for results.

While mandibular molar widths in the two surgical groups and the control group expanded very little, the nonsurgical expansion group experienced a 1.57 mm cross-arch widening. This expansion decreased by 0.38 mm or 24% by the time follow-up records were taken. Nevertheless, this increase marked a significant diversion from the other three groups. Analysis of variance yielded an F-statistic of 3.867 and a P-rating of 0.016.

Maxillary molar widths, as measured at the buccal grooves, expanded by 5.9 mm in the NS group, 3.4 mm in the BC group, and 5.5 mm in the CS group. The C group experienced an 0.8 mm reduction in width during treatment. After treatment, each group rebounded toward its pretreatment width: NS 0.7 mm or 12%; BC 0.2 mm or 5%; and CS 0.3 mm or 6%. The control group returned toward its original width by widening 0.2 mm. Each of the expansion groups showed statistically significant changes in arch width, relative to the C group (F = 10.134; P = 0.001). And, while the NS group expanded 2.6 mm more than the BC group, Scheffe comparisons did not show a significant difference between the two groups.

Intercanine expansion: When measuring the cross-arch widths of the mandibular canines, either at the widest labial contour or at the cusp tips, all groups bore highly similar pretreatment widths and there were no significant arch width changes during the study. In every group, mandibular canine widths expanded: 1.7 mm in the NS group, 0.9 mm in the BC group, and 1.5 mm in the CS group; in each there was a relapse of between 10% and 33%. No significant differences appeared among the groups.

Each expansion group experienced highly significant expansion between the maxillary canines. The expansion averaged about 3.5 mm, compared with 0.8 mm of widening in the control group (F= 5.806; P= 0.002). As measured at the most labial contour, the expansion of maxillary canine width was 3.4 mm in the NS group, 4.3 mm in the BC group, and 3.5 mm in the CS group. The relapse was 0.9 mm or 26% in the NS group, 0.2 mm (5%) in the BC group, and 0.5 mm (14%) in the CS group. These differences were not statistically significant and did not affect clinical stability.

Depth of palatal vault: The impact of surgery on the palatal contour is clearly different from the impact of nonsurgical treatment. While the NS group experienced a minor deepening of the palate between the premolars and essentially no change between the molars, the BC group experienced reductions in height of 0.5 mm between the premolars and 1.0 mm between the molars. In the CS group, which had a total reflection of the palatal mucosa, the palatal contour was radically altered in some patients, and the mean reductions in depth were 1.3 mm between the premolars and 1.9 mm between the molars. Changes in the C group were negligible. The differences between the groups were significant.

Analysis of variance yielded an F-statistic of 6.977 or P = 0.003 at the molars and F = 8.056 or P = 0.001 at the premolars.

Only the CS group experienced an appreciable change (relapse) posttreatment, and the change did not test to be significant. The deepening of 0.5 mm may well represent continued postsurgical healing and remodeling.

Palatal width changes: Using the technique discussed above, it was found that the width of the palatal vault increased 3.3 mm between the premolars for the NS group, 3.6 mm for the BC group, and 4.9 mm for the CS group. There were no statistical differences among the expansion groups between the premolars. The C group showed very minor changes, easily attributable to measurement error.

Between the molars, palatal width increased by 2.3 mm in the NS group, 3.1 mm in the BC group, and 4.9 mm in the CS group. The dramatic increase for the CS group was significantly different from the other two groups. (F = 4.669; P = 0.016)

Tipping: None of the groups demonstrated much tipping at the premolar or molar areas. In the NS group, the average cusp tip position increased 0.08 mm at the molars which translates to less than 1 degree of buccal crown torque. Both of the surgical groups experienced molar uprighting of 0.3 mm, or approximately 3 degrees. There was no significant relapse.

At the premolar area, all groups showed tipping toward the buccal, 0.2 mm in the NS group, 0.1 mm in the BC group, and 0.4 mm or nearly 5 degrees in the CS group. It should be noted that, on the pretreatment study casts, the lingual cusp was about 0.6 mm longer than the buccal cusp in all expansion groups. There were no significant differences among treatment group responses due to expansion. The relapse was negligible. By comparison, the nonexpanded control group experienced a very similar 0.4 mm increase in cusp height and a 0.1 mm rebound after treatment.

Clinical crown length: One area where the differences between surgical expansion and nonsurgical expansion showed a profound, clinically significant difference was in the posttreatment crown lengths of the premolars and molars.

In the NS group, premolar crown length demonstrated an immediate treatment response, increasing by 0.7 mm. While crown length in the CS group increased by 0.2 mm, the BC group experienced a 0.2 mm reduction. (F = 5.611; P = 0.003).

When total treatment response—the difference between the original and follow-up records—was assessed, premolar crown lengthening was 1.2 mm for the NS group, 0.5 mm for the two surgical groups, and 0.6 mm for the controls. Scheffe comparisons demonstrate that the NS group differed from BC and CS (F =4.306; P = 0.011). The surgically assisted patients had less crown elongation than either the controls or nonsurgically treated patients.

Crown height of the molars also increased in the nonsurgical group, significantly more than in the two surgical groups. Molar crowns length increased by 0.8 mm in the NS group during treatment, 0.04 mm in the SB group, and 0.3 mm in the CS group. By comparison, maxillary molar crown length decreased 0.3 mm in the control group, arguably due to gingival hypertrophy at debanding. (F = 4.162; P = 0.012). The differences in the follow-up responses were also significant. Maxillary molar crown length increased 1.3 mm in the NS group, 0.5 mm in the BC group, 0.7 mm in the CS group, and 0.4 mm in the control group. These differences were significant (F = 3.273; P = 0.032). The NS group experienced significantly more crown elongation than any other treatment group.

Increases in crown length did not pose a major problem for any group, either during treatment or during the follow-up period. The gingival

Table 2
Results

	Start	Deband	Follow-up ***	Tx change	Relapse	Net change
	Width at buccal grooves			Treatment change		
Non-S	53.25 (4.4)	54.82 (3.9)	54.44 (3.9)	1.57 (1.7)	-0.38 (0.8)	1.19 (1.7)
Buc-S	50.59 (4.8)	50.54 (3.4)	50.42 (3.4)	-0.05 (1.5)	-0.03 (.70)	0.03 (1.1)
B+P-S	51.60 (3.7)	51.32 (3.1)	51.41 (2.7)	-0.28 (1.8)	0.14 (1.1)	-0.08 (1.6)
Control	51.09 (3.6)	50.58 (2.3)	50.63 (2.6)	-0.51 (1.8)	0.05 (.50)	-0.45 (1.9)
F =				3.867	.409	1.547
P =				0.016	.747	0.219
(V1, V2)				3,40	3,37	3,37
	Width lower canines			Treatment changes		
Non-S	30.38 (2.7)	32.08 (1.9)	31.66 (2.1)	1.71 (1.6)	-0.42 (.8)	1.29 (1.40)
Buc-S	30.42 (2.1)	31.34 (1.0)	31.00 (1.7)	0.91 (1.3)	-0.35 (.7)	0.32 (.6)
B+P-S	30.38 (1.5)	30.94 (2.0)	30.64 (2.3)	0.56 (1.5)	-0.28 (.8)	0.23 (1.7)
Control	30.43 (1.7)	30.60 (2.5)	30.16 (2.5)	0.17 (2.0)	-0.44 (.5)	-0.28 (2.3)
F =				2.005	.118	1.906
P =				0.129	0.949	0.145
(V1,V2)				3,40	3,38	3,38
	Width at buccal grooves			Treatment changes		
Non-S	48.78 (4.2)	54.26 (3.3)	53.70 (2.9)	5.48 (4.0)	-0.34 (0.8)	5.24 (3.6)
Buc-S	52.93 (4.5)	58.83 (4.5)	58.11 (4.3)	5.90 (2.3)	-0.72 (0.6)	5.18 (2.3)
B+P-S	49.74 (3.5)	53.12 (3.8)	52.97 (4.4)	3.39 (1.8)	-0.22 (0.4)	3.10 (2.0)
Control	54.50 (4.1)	53.72 (3.1)	53.93 (3.2)	-0.78 (1.4)	0.21 (0.9)	-0.57 (1.1)
F =				10.134	2.923	9.109
P =				0.001	0.046	0.001
(V1,V2)				3,40	3,38	3,38
	Upper canine width at most labial surface			Treatment changes		
Non-S	36.86 (2.9)	40.30 (2.1)	39.40 (2.6)	3.44 (1.7)	-0.90 (1.0)	2.53 (1.6)
Buc-S	34.55 (1.6)	38.81 (0.9)	38.38 (0.6)	4.26 (1.5)	-0.20 (0.4)	3.85 (1.4)
B+P-S	35.31 (2.9)	38.76 (1.9)	38.31 (1.8)	3.45 (2.1)	-0.47 (0.6)	2.81 (2.0)
Control	38.16 (1.4)	38.91 (1.8)	38.74 (1.9)	0.75 (0.5)	-0.17 (0.2)	0.57 (0.7)
F =				5.806	2.460	4.880
P =				0.002	0.078	0.006
(V1,V2)				3,40	3,38	3,38
	Palatal depth at premolars			Treatment change		
Non-S	16.0 (1.8)	16.4 (1.9)	16.7 (1.92)	.04 (.08)	.31 (.56)	0.7 (.86)
Buc-S	18.1 (2.8)	17.6 (2.4)	17.5 (2.6)	-.52 (.095)	.22 (.56)	0.3 (1.15)
B+P-S	18.0 (2.1)	16.5 (1.5)	16.64 (1.7)	-1 (1.5)	-.08 (1.03)	-1.4 (2.08)
Control	17.4 (2.6)	17.3 (2.1)	17.2 (2.2)	-.09 (1.42)	-.09 (.41)	-.2 (1.31)
F =				4.764	.908	4.720
P =				0.006	0.446	0.007
(V1,V2)				3,39	3,37	3,37
	Palatal depth at molars			Treatment change		
Non-S	21.4 (2.79)	21.4 (3.1)	21.4 (3.04)	-0.01 (1.03)	.79 (.72)	0.6 (1.0)
Buc-S	22.6 (2.13)	21.6 (2.14)	21.6 (2.66)	-1.01 (.77)	.89 (.70)	-.88 (.91)
B+P-S	22.6 (2.0)	20.7 (1.70)	21.1 (1.71)	-1.9 (.85)	.45 (.94)	-1.5 (1.5)
Control	22.6 (2.83)	22 (2.44)	22.5 (2.15)	-.40 (.55)	.40 (.46)	-.01 (.98)
F =				5.295	.774	4.78
P =				0.004	0.516	0.006
(V1,V2)				3,39	3,37	3,37

Table 2, continued
Results

	Start	Deband	Follow-up ***	Tx change	Relapse	Net change
	Palatal width at premolars			Treatment change		
Non-S	18.4 (4.03)	21.6 (4.1)	21.5 (4.74)	3.2 (1.5)	-.1 (1.14)	3.1 (2.03)
Buc-S	15.2 (3.16)	18.7 (3.4)	19.0 (3.84)	3.56 (2.2)	.21 (.76)	3.65 (2.24)
B+P-S	15.1 (4.3)	18 (3.3)	17.92 (3.71)	9.9 (3.1)	.03 (1.44)	4.91 (3.12)
Control	20.6 (1.07)	20.9 (2.3)	20.4 (2.5)	.30 (1.26)	-.5 (1.0)	-.21 (1.24)
				F = 6.718	.722	7.132
				P = 0.001	0.517	0.001
				(V1,V2) 3,39	3,37	3,37
	Tipping at molars (averaged)			Treatment change		
Non-S	.32 (.74)	.40 (.50)	.40 (.50)	.07 (.60)	0.00 (.24)	.08 (.70)
Buc-S	.50 (.51)	.23 (.43)	.17 (.40)	-.30 (.55)	-.10 (.40)	-.43 (.34)
B+P-S	.52 (.51)	.21 (.50)	.31 (.15)	-.31 (.43)	.12 (.30)	-.22 (.40)
Control	.07 (.51)	.32 (.70)	.40 (.70)	.25 (.50)	.08 (.43)	.33 (.43)
				F = 2.669	.780	3.160
				P = 0.061	0.513	0.036
				(V1,V2) 3,39	3,37	3,37
	Tipping at premolars (averaged)			Treatment change		
Non-S	.61 (.4)	-.42 (.53)	-.54 (.55)	.19 (.53)	-.12 (.35)	.88 (.42)
Buc-S	-.07 (1.07)	-.06 (.51)	-.53 (.90)	.11 (.60)	.14 (.40)	.30 (.40)
B+P-S	-.60 (.70)	-.16 (.64)	-.45 (.50)	.43 (.64)	-.23 (.40)	.20 (.50)
Control	-.09 (.40)	-.50 (.54)	-.62 (.60)	.40 (.40)	-.12 (.18)	.30 (.51)
				F = .724	1.359	4.04
				P = 0.544	0.271	0.751
				(V1,V2) 3,38	3,36	3,36
	Gingival stripping at canine, length of canine (averaged)			Treatment change		
Non-S	9.7 (1.15)	9.85 (1.30)	9.75 (1.0)	.17 (.53)	-.10 (.60)	.07 (.51)
Buc-S	9.61 (.83)	9.75 (.70)	10.13 (.70)	.21 (.80)	.24 (.16)	.42 (.94)
B+P-S	10.09 (1.3)	10.13 (1.06)	10.35 (1.21)	.04 (.05)	.14 (.40)	.15 (.64)
Control	10.55 (1.9)	10.35 (1.45)	10.6 (1.8)	-.20 (.70)	.24 (.50)	.04 (.60)
				F = .787	1.351	.444
				P = .508	0.273	0.723
				(V1,V2) 3,38	3,37	3,36
	Gingival stripping at premolars, length of premolars (averaged)			Treatment change		
Non-S	7.54 (.90)	8.12 (1.01)	8.8 (1.25)	.70 (.55)	.70 (.60)	1.24 (.06)
Buc-S	7.92 (1.06)	7.7 (1.1)	8.4 (1.34)	-.24 (0.85)	.60 (.90)	.51 (1.09)
B+P-S	7.65 (1.15)	7.9 (1.2)	8.15 (1.42)	.25 (.40)	.25 (.43)	.53 (.63)
Control	7.62 (.95)	7.5 (.75)	8.24 (.85)	-.53 (.53)	.74 (.70)	.61 (.82)
				F = 5.611	1.491	4.306
				P = 0.003	0.233	0.011
				(V1,V2) 3,38	3,36	3,37
	Gingival stripping at molars, length of molars (averaged)			Treatment change		
Non-S	6.33 (.85)	7.12 (1.00)	7.61 (1.00)	.80 (.65)	.50 (.61)	1.30 (.50)
Buc-S	6.92 (1.43)	6.1 (1.6)	7.44 (1.9)	.04 (1.07)	.40 (1.16)	.50 (.50)
B+P-S	6.36 (1.01)	6.64 (1.3)	7.05 (1.45)	.30 (.70)	.43 (.53)	.70 (1.03)
Control	7.60 (.92)	7.3 (.70)	8.0 (.92)	-.32 (.67)	.71 (.51)	.40 (.67)
				F = 4.164	.315	3.273
				P = 0.012	.814	0.032
				(V1,V2) 3,39	3,37	3,37

level receded 0.17 mm in the NS group, 0.21 mm in the BC group, and 0.04 mm in the CS group. In the C group, crown height actually was reduced during treatment (perhaps due to gingival swelling after debanding) and returned to the pretreatment value by the follow-up appointment. There were no statistical differences in treatment responses.

Palatal volumetric change: Changes in palatal width and depth were used to calculate any changes in volume that took place during expansion. In making the calculations, the average distance between the premolar palatal mark and the molars, 24 mm, was used to determine the net volumetric change in the space where measurements were taken. The mean absolute changes in palatal width and palatal height were multiplied by this arbitrary depth of 24 mm to determine the palatal volumetric change.

The average volumetric increases were 1,368 cubic millimeters in the NS group, 1,342 in the BC group, 2,545 in the CS group, and 46 cubic millimeters in the C group. These measurement pertain only to the space between the premolar and the molar; it would be far more difficult to calculate the increased volume in the entire mouth.

Discussion

It would appear that all the expansion techniques examined in this study provide adequate correction of transverse discrepancies. It is not relevant to compare the amounts of expansion achieved, as transverse needs vary from case to case. What is relevant is that adequate expansion is achieved to correct the crossbite or other functional needs of a particular case. As shown by Haas, Lehman, Pogrel, Bays and others, maxillary expansion is a highly useful and relatively stable clinical approach to the correction of transverse deficiencies of the maxilla. The amounts of expansion and percentages of relapse shown in this study are in keeping with other studies. More importantly, all crossbites were corrected by expansion procedures, and they all remained corrected. See Table 3 for a comparison of studies in the literature.

Of the 20 cases Haas provided, 18 demonstrated posterior crossbite at the outset. All were corrected and all remained crossbite-free at the time of the follow-up records. All the surgical cases were in buccal crossbite prior to treatment and all of these crossbites were also corrected during treatment. There were only two patients in the CS group who had residual crossbites at the time of follow-up records—in both cases a single tooth discrepancy reoccurred where there had been complete buccal crossbite and a great deal of pretreatment irregularity.

When considering differences in intercanine and intermolar widths, it is important to remember that cases needing palatal expansion often have labially occluded canines. These blocked-out canines can be moved into narrower positions with the alignment that takes place when the transverse discrepancy has been resolved; consequently, canines will not show as much width increase as molars.

Our findings indicate that expansion in the mandibular arch is not entirely stable. While Haas showed cases of spontaneous mandibular expansion accompanying clinically imposed maxillary expansion, the relapse that ultimately occurred in his cases provide reason to believe that the expansion was not predictably stable in nongrowing individuals. Other studies that have examined the stability of mandibular arch changes in patients who undergo maxillary expansion also fail to show postretention stability.[24,25]

We have no explanation for the fact that the molar widths of the nonsurgically treated expansion patients in this study are wider than those of the surgically treated patients. Perhaps patients from northern Ohio have broader faces than those in northern Michigan, and yet still present with similar transverse discrepancies.

Our study documents a reduction in palatal depth following surgery, especially in the combined surgery case, which increases slightly in the follow-up records. This may be due to reorganization of the scarring that persists as swelling at the time of debanding records.

The curiosity that led us to measure palatal depth was the conviction that the volume of the palatal vault or the "tongue cage" increases during treatment, giving the tongue more space in which to function and, theoretically, a more stable resting position. It seems logical, then, that the size of the oral cavity might be a predictor of stability. In considering our findings, especially the volumetric increases calculated, it would seem prudent to consider the combined surgical approach in treating cases where the constriction of the maxilla severely impacts appropriate positioning of the tongue at rest. This procedure provided nearly twice the volumetric increase that buccal corticotomies or nonsurgical expansion yielded.

According to our findings, none of the expansion modalities results in appreciable buccal flaring or tipping. While Wertz[26] found that tipping

Table 3
Comparison of palatal expansion studies

	Sample size	Procedure	Amount of expansion At molar (relapse)	At canine (relapse)
Bays and Greco	16 females / 3 males	Buccal corticotomy	5.8 mm (0.5)	4.5 mm (0.3)
Northway	7 females / 9 males	Nonsurgical	5.5 mm (0.3)	3.4 mm (0.9)
	7 females / 0 males	Buccal corticotomy	5.9 mm (0.7)	4.3 mm (0.2)
	10 females / 6 males	Combined surgery	3.4 mm (0.2)	3.5 mm (0.5)
	4 females / 3 males	Control	-0.8 mm (0.2)	0.7 mm (0.2)
Phillips	39	LeFort I surgical exp.	5.4 mm (2.6)	1.25 mm(0.1)
Pogrel	12	Combined surgeries	7.5 mm (0.9)	n/a
Turvey	104	LeFort I surgeries	3 - 13 mm	n/a

was a demonstrable response to expansion and Moss[27,28] demonstrated that the anchoring teeth tipped, it must be remembered that the cases reviewed in this investigation were also treated with a complete course of Edgewise orthodontics, which should eliminate or reduce much of the tipping. Furthermore, the net effect of some flaring was to improve interdigitation of the posterior teeth. Many of the cases that need expansion present with teeth that are already tipped to the lingual. Uprighting of these teeth can improve interdigitation.

In the author's experience, nonsurgically assisted palatal expansion in adults has resulted in an extended period of pain or severe discomfort, and a significant amount of gingival recession.

Greenbaum and Zachrisson,[29] using four periodontal parameters, found "minimal differences in periodontal condition" due to either slow or rapid expansion in children. While we were unable to use their criteria, we found no teeth that were severely compromised from a periodontal perspective, even in the follow-up records. However, the increase in molar and premolar crown length in the nonsurgical expansion cases was twice that of any of the other treatment groups. We are uncomfortable with this degree of what we believe to be gingival recession. Although the NS group had been out of treatment 11.8 years, one of the tests of stability is how a case holds up over time. The average age at the time of the follow-up records was 36.1 years. The average age of the BC group at the follow-up was 34.7 years; the CS group was 33.4 years; and the average age of the C group was 42.2 years. We believe that such exaggerated increases in crown length are due more to expansion technique than to age.

In a study where Warren et al.[30] demonstrated improved nasal respiration in 7 of the 12 individuals judged to have impaired nasal airways, the conclusion was that "maxillary expansion for airway purposes alone [was] not justified." Of the 14 nasally impaired adults who were treated with surgically assisted expansion, 8 were judged not to be nasally impaired following treatment. Authors indicated that interpretations in their study were "based on extrapolated information from analog of what would be sufficient nasal passage volume to allow normal respiration." These findings would seem to agree with previous authors,[31,32] who concluded that "rapid maxillary expansion reduces nasal airway resistance and improves nasal breathing."[33-35] We lack the armamentarium to test the influences of expansion on nasal respiration, but it is our subjective impression that the patients who underwent a combined surgical procedure experienced greater respiratory improvement than those who had buccal corticotomies alone, and the control group reported no change.

It should be noted that the surgical procedure involved in each of these cases was performed in the office of an oral surgeon, on an out-patient basis, with intravenous Versed-Demeral sedation. The physical impact and management of the patients is similar to having wisdom teeth removed. Oral surgeons who use this technique do not separate the pterygomaxillary fissure because of the aggressive nature of osteotome usage and possible adverse stimulation of a patient who is merely sedated. There is no apparent need to separate the pterygoid plates from the tuberosity. Such a separation requires extreme force, usually causes the plates to fracture into a number of pieces, and is not considered necessary.

The in-office procedures detailed in this article are far less costly, and again less risky, than a Le Fort down-fracture, which would require hospitalization. Further, there are difficulties associated with providing expansion with a down-fracture. The palatal tissues are very dense, and a lack of separation at the apex of the palate makes it difficult to provide much more than a tipping of buccal segments. Surgeons who have attempted expansion both ways will relate the difficulty in completely engaging the surgical stint well into the palate at the time of surgery. Too much expansion at one time compresses the palatal mucosa, compromising the vascularity and hence the success of the procedure.

Developing the expansion over a couple of weeks with a full coverage palatal expander, *a la* Haas, allows for vascular adaptation and provides far more orthodontic-type control over the expanded segments. Publications that advocate expanding with a stent at the time of surgery report that tremendous relapse (lack of control) occurs in the aftermath of surgical expansion.[36,37]

Another consideration at play in the choice of procedures is the potential for influencing partial obstruction of the nasal passages. Should the expansion result in an uneven separation on either side of the septum, at any point along the septum, a deviation may occur. Conversely, providing an incision on one side of the nasal septum during the midline surgery might provide more opportunity for expansion on the partially occluded side of the nasal passages, not to mention the affected side in an asymmetrical crossbite.

Haas[38] contends that, in adults, he doesn't see the same kind of "orthopedic expansion" that children experience with rapid palatal expansion. Rather, he expands more slowly; and he contends that there is a combination of membranous warpage and some sutural stretching that combine to provide a unique form of expansion, one that is not as kind to the buccal gingival contours, but still clinically adequate and stable. His cases bear this out. It should also be noted that the cases provided by Haas were not consecutively treated, but are cases selected from his practice that he and many other examiners are using to document the efficacy of orthopedically achieved maxillary expansion in adults.

Finally, Haas retains his expansion cases with a Hawley-type retainer worn at night, for life if the patient will agree. As we routinely provided a positioner for the patient to wear after debanding, Haas's approach has caused a rethinking of the retention regimen, especially in cases where there is significant intra-arch irregularity at the beginning of treatment. If nothing more than to provide a template for the patient to verify stability periodically, the rigidity of a maxillary Hawley retainer provides excellent support to the maxilla in these cases.

In conclusion, the selection of an expansion technique depends on a number of factors. Certainly the cost of a surgical approach must be factored in, as does the patient's tolerance for pain and an extended course of expansion. Some patients are not receptive to the idea of surgery. On the other hand, the surgery can be done in conjunction with the removal of third molars, typically without much increase in morbidity. It has been our experience that surgically assisted rapid maxillary expansion for a true buccal crossbite in adults is the easiest and most predictable approach.

We become more likely to advocate surgery as the patient's age, transverse needs, or acceptance of the idea of surgery increases. When there is greater need for increased lingual volume, especially at the palatal apex, the surgeon might be encouraged to provide a bilateral separation on either side of the palatal suture, as well as the buccal corticotomy. Too many patients in their late teens have spent sleepless nights, without sufficient pain killers to provide comfort, waiting to see if the palatal suture is going to release. All things being equal, we much prefer the surgical alternative; and we don't feel that we compromise the peridontium as much as unassisted, orthopedic expansion does.

Summary

1. Maxillary expansion in adults, both orthopedic as advocated by Haas and surgically assisted, is predictable and stable; typical expansion is 3.5 mm at the maxillary canines and 5.5 mm at the molars. Corrected crossbites remain corrected.

2. Depth of the palate is reduced during treatment in both surgical groups.

3. Palatal width increases significantly, especially when buccal corticotomies are accompanied by a palatal split.

4. Palatal expansion, followed by a full course of edgewise orthodontic treatment, results in very controlled, beneficial tipping.

5. Clinical crown length increased more in the premolars and molars in nongrowing patients who were expanded in the absence surgery.

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