Cephalometric Point "A" Position Following Palatal Expansion

Položaj kefalometrijske točke "A" nakon širenja nepca

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Summary

Objectives: *Palatal expansion is used to treat severely constricted maxillary arches associated with a posterior unilateral of bilateral crossbite. The purpose of this study was to evaluate the affects of such treatment on the position of the "A" point.*

Material and Methods: *Ninety six cases where palatal expansion was the first orthodontic treatment were retrospectively analyzed using lateral cephalographs taken before and after the expansion phase. Vertical movement of "A" point was assessed relative to the perpendicular distance from the Frankfort Horizontal Plane and from the anterior cranial base (Sella-Nasion). Horizontal movement of "A" point was measured parallel to the Frankfort Plane using a line tangenital to the posterior limit of the pterygomandibular fissure and also parallel to the anterior cranial base from point Sella. Subgroups of "rapid" and "slow" palatal expansion were compared.*

Results: *Here was a mean downward and forward movement of point "A" during palatal expansion, with displacement being greater on average with rapid than with slow palatal expansion therapy. The mean vertical component changes relative to speed of palatal expansion was statistically significant ($p<0.1$). The horizontal component averaged > 1 mm more with rapid palatal expansion compared to slow expansion; however, no statistical significance was proven. Mean increase in the mandibular plane angel was 1.4° to 2.0°.*

Conclusions: *Palatal expansion is generally associated with a downward and forward movement of point "A" which is greater on average with rapid than with slow activation therapy.*

Key words: *cephalometrics, orthodontic therapy, palatal expansion therapy.*

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The constricted maxillary arch is often associated clinically with bilateral or unilateral crossbite of the dentition and may also hinder development of a normal mandibular arch. Rapid palatal expansion is frequently used in orthodontic practice to treat this condition. In the process, the mid-palatal suture is forcibly separated over a period of two to four weeks using a screw expansion appliance activated to approximately 0.5 mm per day. To prevent relapse this is followed by passive retention for a period of three months while bone fills in at the open suture (1,2). The alternative to rapid palatal expansion is a slower activation regimen using activation of approximately 0.5 to 1.0 mm per week. With this slower regime a long period of retention is not needed as bone fills in during treatment and skeletal side-effects are minimized (3-5). It is accepted that both methods produce equal stability(1,6-9). However, a side effect reported in rapid palatal expansion is the downward and forward migration of the cephalometric "A" point (the position of great bony concavity on the maxillary anterior surface). Such "A" point translocation could exacerbate a pre-existing skeletal Class II or anterior open bite situations, and it can complicate the treatment of patients with a high mandibular plane angulation. Conversely, the downward and forward movement of point "A" could aid in the correction of skeletal Class III and anterior deep overbite conditions.

The purpose of this study were: (1) to quantify "A" point migration during palatal expansion; (2) to quantify changes in the mandibular plane angle subsequent to palatal expansion; and (3) to compare changes occurring through use of rapid and slow palatal expansion regimens.

Material and methods

A retrospective analysis was made of cephalographs taken both before, and one to three months following, palatal expansion in 96 individuals; 60 females and 36 males. The subjects ranged in age from six to 22 years, with an arithmetic mean age of 12.7 years. Palatal expansion was the first orthodontic treatment; hence no other treatment could have affected the position of the cephalometric "A" point. The period of expansion ranged from 17 to 113 days, averaging 40 days.

A Wehmer® cephalometer (Forrest Park, Illinois) standardized the beam geometry and a metric scale was present to ascertain magnification. The film used was either BB-4® or XL-1® (Eastman Kodak, Rochester, NY). Exposures were made at 75 kVp and 5 mAs.

Tracings were digitized using the short regimen of the Dentofacial Planner® (Toronto, Canada) cephalometric program. To determine the accuracy of digitization by the second author, every fourth case was traced by a second orthodontist for comparison of pre-expansion measurements. A 10% magnification was factored in all linear measurements. The posterior and anterior cranial base lengths (Sella-Basion [SBa] and Sella-Nasion [SN] respectively) were used be expected during the relatively short treatment regimens applied.

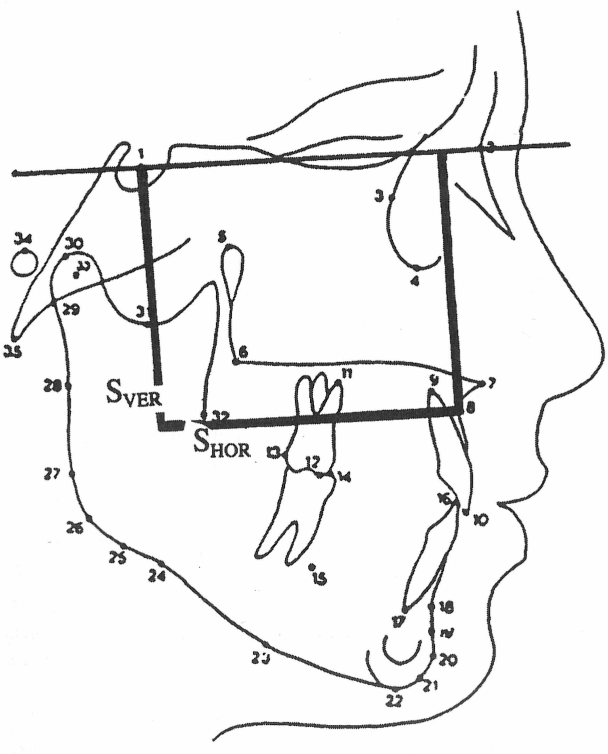

Figure 1. *Linear cephalometric measurements S_{HOR} and S_{VER} employed, based upon Sella/anterior cranial base*

Slika 1. *Linearna kefalometrijska mjerenja S_{HOR} i $_{SVER}$ prema liniji sella/baza prednje lubanjske jame*

Vertical movement of cephalometric point "A" was assessed relative to the perpendicular distances from the Frankfort Horizontal (FH) and, using SN, from the anterior cranial base (Figure 1, 2). Horizontal movement of the "A" point was measured parallel to FH, from a vertical line tangential to the posterior limit of the pterygomandibular fissure (PH) and perpendicular to FH (Figure 2). Horizontal movement of the "A" point was also assessed parallel to the anterior cranial base from point Sella (Figure 1). Parallel descent of the maxilla was determined by comparing pre-and post-expansion relationships of the palatal plane to the FH and to the SN planes.

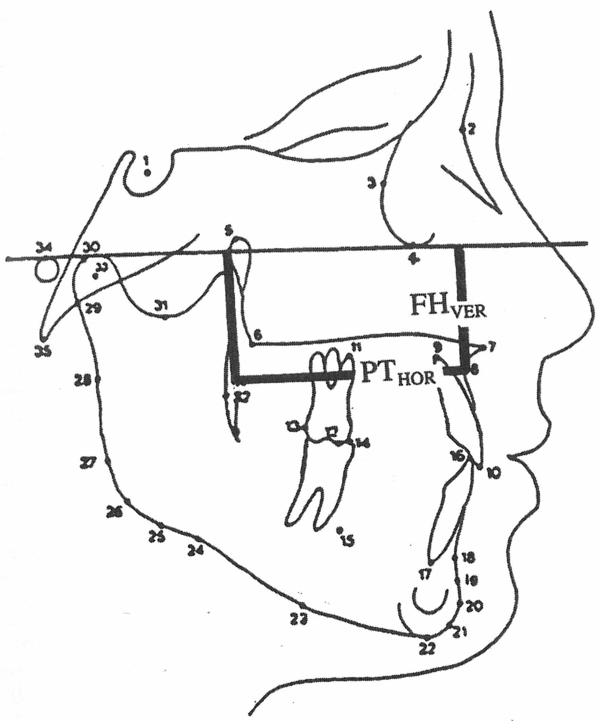

Figure 2. *Linear cephalometric measurements PT_{HOR} and FH_{VER} employed, based upon vertical line tangential to posterior extent of pterygomaxillary fissure and horizontal line parallel to Frankfort Horizontal*

Slika 2. *Linearna kefalometrijska mjerenja PT_{HOR} i FH_{VER} prema okomici koja dodiruje stražnji dio perigomaksilarne fisure i vodoravnoj crti usporednoj s Frankfurtskom ravninom*

Opening of the bite was measured by comparing the pre- and post-treatment SN to mandibular plane (MP), and the FH to MP angles. [The cephalometric abbreviations are explained in Table 1].

The subject sample was divided into three equal size subgroups of 32 individuals each based upon

Table 1. *Acronyms and Definitions*

Tablica 1. *Skraćenice i tumačenje pojmova*

ACRONYM	DEFINITION
"A" point	Greatest contavity of anterior surface of bony maxilla
D	Difference between pre- and post-expansion value
FH	Frankfort Horizontal plane (Orbitale to Porion)
FH-MP	Angle between FH and to mandibular plane (MP)
FH-PP	Angle between FH and palatal plane (PP)
FH_{VER}	Perpendicular distance from FH to "A" point
MP	Mandibular plane (Gonion to Menton)
PP	Palatal plane (Anterior Nasal Spine [ANS] to Posterior Nasal Spine [PNS]
PT	Most posterior surface of pterygomaxillary fissure
PT_{HOR}	Distance from PT to "A" point parallel to FH
SBa	Distance from Sella to Baison (posterior cranial base)
SN	Distance from Sella to Nasion (anterior cranial base)
SN-MP	Mandibular plane angle
SN-PP	Palatal plane angle
S_{HOR}	Distance from Sella to "A" oint parallel to SN
S_{VER}	Perpendicular distance from SN to "A" point

the time over which palatal expansion was accomplished (rapid = 17 to 24 days; intermediate = 25 to 41 days; slow = 42 to 113 days). For fast palatal expansion the average patient age was 14.2 years (the age difference was statistically significant when subjected to the unpaired *t-test*).

Overall changes were evaluated using two-tailed *t-tests*. Measurements from the rapid palatal expansion subgroup were compared to those from the slow palatal expansion subgroup using unpaired *t-tests*. These measurement included; (1) the palatal expansion rate, (2) changes in the distance from Sella to the cephalometric "A" point parallel to the plane (ΔS_{HOR}), (3) changes in the distance from the most posterior portion of the pterygomaxillary fissure to FH to the cephalometric "A" point, parallel to the FH plane (ΔPT_{HOR}), (4) changes in the perpendicular distance from SN to "A" point (ΔS_{VER}), (5) changes in the perpendicular distance from the FH to "A" point (ΔFH_{VER}), (6) changes in the MP angle measured between SN and Gonion-Menton (ΔSN-MP), (7) changes in the MP angle measured to the FH (ΔFH-MP), (8) changes in the SN to palatal plane (PP) angle (ΔSN-PP) and (9) changes in the FH to PP angle (ΔFH-PP) The *á priori* α was set at $p < 0.05$ for all statistical inferences.

Results

Controls: For the controls (SN and SBa), differences in the pre- and post-treatment measurements were 0.02 mm and 0.01 mm respectively (Table 2). These discrepancies were not statistically significant ($p>0.1$). There was a high degree of correlation between the two orthodontics independently making these and the other measurements: regression analyses yielded R2 values ranging from 0.94 to 1.00 (Table 3).

Angular measurements (mandible): For all subgroups combined, ΔFMA and ΔSN-MP angulation increased an average of 1.66° and 1.80° respectively. These differences were statistically significant ($p<0.01$). Regression analyses for ΔFMA and ΔSN-MP yielded R^2 values of 0.84 and 0.86 respectively (Table 3). Opening of the bite was observed in most cases; however, in 16 there was slight closing of the bite relative to SN and in 17 there was slight closing of the bite relative to FH.

Angular measurements (maxilla): For all subgroups combined, the average changes in ΔSN-PP and ΔFH-PP angulations were -0.20° and 0.08° respectively. These changes were not statistically significant ($p>0.1$), suggesting (on average) an absence of maxillary rotation. Nevertheless, there was wide individual variation: the range of change for ΔSN-PP was from -4,5° to +4.2°; for ΔFH-PP it was -4.8° to 4.2°. A positive change in these angles indicated an inferior movement of the posterior nasal spine (PNS). Of the 96 individuals studied, 46 registered a change within the range ± 1° for ΔSN-PP; 52 displayed a ±1° range for ΔFH-PP.

Table 2. *Summary of Findings*
Tablica 2. *Sažetak nalaza*

CRITERION STUDIED	RAPID (17-24 days) Average (±sd)	INTER (25-41 days) Average (±sd)	SLOW (42-113 days) Average (±sd)
Subject age (years)	11.6(±1.9)	12.4(±2.1)	14.2(±3.0)
Duration (days)	22.0(±1.7)	31.4(±4.8)	65.6(±17.9)
SN start (mm)	66.2(±3.1)	67.6(±3.4)	68.2(±3.8)
SN end (mm)	66.3(±3.3)	67.7(±3.6)	68.2(±3.8)
ΔSN (mm)	0.09(±0.51)	0.03(±0.54)	-0.06(±0.54)
SBa start (mm)	43.6(±2.3)	45.1(±2.9)	44.3(±3.5)
SBa end (mm)	43.6(±2.5)	45.0(±3.1)	44.3(±3.4)
ΔSBa (mm)	0.08(±1.63)	-0.05(±1.21)	-0.02(±1.42)
SN-MP start	39.0(±5.3)°	36.7(±5.0)°	37.5(±5.6)°
SN-MP end	41.2(5.3)°	38.4(±4.6)°	39.0(±5.4)°
ΔSN-MP	2.22(±2.00)°	1.68(±1.76)°	1.50(±2.14)°
FH-MP start	28.8(±5.3)°	27.1(±4.0)°	27.4(±4.7)°
FH-MP end	30.9(±5.2)°	28.6(±3.7)°	28.8(±4.7)°
ΔFH-MP	2.05(±1.98)°	1.54(±1.66)°	1.39(±2.02)°
SN-PP start	-8.0(±4.2)°	-6.3(±3.7)°	-7.9(±2.8)°
SN-PP end	-8.4(±4.2)°	-6.5(±4.1)°	-8.0(±3.3)°
ΔSN-PP	-0.36(±1.84)°	-0.23(±1.33)°	-0.07(±1.34)°
FH-PP start	2.2(±4.3)°	3.3(±3.1)°	2.1(±3.4)°
FH-PP end	2.0(±4.1)°	3.2(±3.5)°	2.2(±3.9)°
ΔFH-PP	-017(±1.95)°	-0.09(±1.32)°	0.04(±1.30)°
S_{HOR} start (mm)	55.9(±4.6)	58.2(±4.2)	57.2(±4.2)
S_{HOR} end (mm)	56.9(±4.5)	58.9(±4.0)	57.9(±4.1)
ΔS_{HOR} (mm)	0.97(±0.83)	0.73(±1.04)	0.72(±1.12)
PT_{HOR} start (mm)	49.0(±2.9)	50.4(±2.8)	50.3(±4.0)
PT_{HOR} end (mm)	50.2(±3.1)	51.6(±2.6)	51.2(±3.8)
ΔPT_{HOR} (mm)	1.19(±0.86)	1.18(±0.92)	0.89(±0.96)
S_{VER} start (mm)	53.4(±3.9)	52.2(±4.3)	55.7(±3.4)
S_{VER} end (mm)	54.8(±3.9)	53.4(±4.3)	56.5(±3.5)
ΔS_{VER} (mm)	1.48(±0.85)	1.23(±0.76)	0.79(±0.86)
FH_{VER} start (mm)	25.1(±3.2)	24.0(±3.6)	26.9(±3.1)
FH_{VER} end (mm)	26.3(±3.1)	25.0(±3.7)	27.5(±3.2)
ΔFH_{VER} (mm)	1.24(±0.86)	0.96(±0.70)	0.66(±0.71)

Table 3. *Summary of Regression Analyses*
Tablica 3. *Sažetak povratnih raščlambi*

CRITERION	Constant	Std. error Y (est.)	R2	X coeff.	Std. error coeff.
DSHOR	4.65	0.98	0.95	0.93	0.02
DPTHOR	4.66	0.90	0.92	0.93	0.03
DSVER	2.90	0.84	0.96	0.97	0.02
DFHVER	1.79	0.79	0.95	0.97	0.02
DSN-MP	5.32	1.95	0.86	0.91	0.04
DFH-MP	4.32	1.88	0.84	0.90	0.04
DSN-PP/DSN-MP	1.74	1.96	0.05	-0.30	0.13
DFH-PP/DFH-MP	1.64	1.89	0.04	-0.26	0.12

[n=96; dof=94 throughout]

Distance measurements from cephalometric point "A": The average tendency for cephalometric point "A" was downward and forward during palatal expansion. With respect to SN, "A" point moved, on average, 0.81 mm forward and 1.17 mm downward; with respect to FH, it moved 1.09 mm forward and 0.95 mm downward.

These changes were statistically significant ($p < 0.1$). Pre- and post-treatment values demonstrated linearity and a high degree of homoscedasticity.

Regression analyses of the pre- and post-treatment means yielded R^2 values of 0.95, 0.92, 0.96 and 0.95 for ΔS_{HOR}, ΔPT_{HOR}, ΔS_{VER}, and ΔFH_{VER} respectively; however, there was wide individual variation (Table 3). Although the average tendency was for point "A" to move downward and forward, some cases showed downward and backward translocation and some showed superior and forward movement of the cephalometric point "A". Of the 96 cases, 21 showed retro positioning of point "A" relative to SN, while only six demonstrated the same relative to FH. Point "A" moved superiorly relative to SN, while in 10 individuals point "A" moved superiorly relative to FH.

Palatal expansion pace subgroup overview: A summary of he mean values and standard deviations for each of the three subgroups (rapid, intermediate and slow palatal expansion) is given in Table 2. There was a wide individual variation within each of these subgroups; however, mean changes for the rapid palatal expansion subgroup were larger than those found for the slow palatal expansion subgroup.

Subgroup analyses of angular measurements (mandible): For the rapid expansion subgroup, the average change in ΔSN-MP and ΔFH-MP were 2.22° and 2.05° respectively (Table 2); for the slow expansion subgroup these changes were 1.50° and 1.39° respectively. The differences were not statistically significant ($p>0.1$).

Subgroup analyses of angular measurements (maxilla): For the rapid palatal expansion subgroup, the average change in ΔSN-PP and ΔFH-PP were -0.36° and -0.17° respectively; for the slow palatal expansion subgroup these changes were - 0.07° - and +0.04° respectively (Table 2). The differences were not statistically significant ($p>0.1$).

Subgroup distance measurements from "A" point: The average values for changes in ΔS_{HOR} and ΔPT_{HOR} during rapid palatal expansion were 0.97 mm and 1.19 mm respectively; for slow palatal expansion the changes in the comparable values were 0.27 mm and 0.89 mm respectively. The horizontal measurement change differences were not statistically significant ($p>0.1$) (Table 2). The mean changes in ΔS_{VER} and ΔFH_{VER} were 1.48 mm and 1.24 mm with rapid palatal expansion, and 0.79 mm and 0.66 mm respectively for slow palatal expansion (Table 2). The vertical measurement change differences were statistically significant ($p<0.01$).

Discussion

The results of this investigation concur with previous studies in that movement of the cephalometric "A" point secondary to palatal expansion was found on average to be both downward and forward. Unique to our work was the use of two different reference planes (SN and FH). Measurements derived from the SN plane showed greater movement of the cephalometric "A" point vertically than horizontally, while those derived from FH showed more of less equivalence of the cephalometric "A" point translocation in these two dimensions. The FH plane was found to more nearly parallel the PP than the SN plane; hence , FH is to be the preferred reference plane.

It might be considered that the high R^2 results from the regression analyses would make prediction of change in the cephalometric "A" point possible. This would certainly be valuable information in determining outcomes. Unfortunately, however, the prediction limits within the actual regression plots were somewhat variable, and hence the response of the individual patient is unpredictable.

Proffit (1986) characterized rapid palatal expansion as that achieved within three weeks and that for slow palatal expansion as occurring beyond 10 weeks (10). The mean periods of expansion for our fast subgroup (Table 2) fit within Proffit's parameters; however, in our "slow" expansion group almost two-thirds of the patients had expansion rates somewhat "faster" than "slow". To have adhered strictly to Proffit's criteria would have resulted in too small a "slow" expansion subgroup given the available materials for our study. Semantics aside, the less than optimal case selection available might account for some of the ambivalent findings when comparing mean changes in S_{HOR}, PT_{HOR}, S_{VER} and FH_{VER} between the subgroups with only the vertical movement differences evidencing statistical significance. Nevertheless, horizontal differences in translocation of point "A" were approximately 30% greater for the fast palatal expansion subgroup than they for the slow palatal expansion subgroup.

The mean linear changes in the position of the cephalometric "A" point relative to the pterygoid vertical FH(ΔPT_{HOR} and ΔFH_{VER}) for the rapid palatal expansion subgroup were both 1.2 mm. Relative to SN, the mean horizontal change (ΔS_{HOR}) was 1.0 mm, while the vertical change (ΔS_{VER}) averaged 1.5 mm. Previously, Haas (1961) reported an average horizontal increase of 2.1 mm relative to the facial plane for 10 subjects, half of whom exhibited an inferior movement of the cephalometric "A" point (8). In 1969. Davis and Kronman reported that 22 of 26 subjects displayed forward movement of the "A" point relative to he pterygoid vertical (11). Wertz, 1970. described a study of 60 cases in which there was routine downward displacement of the maxilla, but in whom forward horizontal displacement was rarely greater than 1.5 mm relative to Sella, parallel to the SN plane (12). In a further and study of 56 cases, Wertz and Dreskin, in 1977, showed cephalometric point "A" advanced and moved inferiorly on average 0.5 mm relative respectively to the pterygoid root plane and FH (13). In 1978, Bhatt and Jacob reported seven cases for whom the average advancement of point "A" from Sella, parallel to SN, was 2.1 mm (14).

Relative to clinical relevance, accepting a change of 1 mm or greater in the cephalometric "A" point relative to PT_{HOR} as being clinically important (as in the correction of a pseudo-Class III anterior crossbite), 69% of individuals in our rapid palatal expansion subgroup evidenced such a change. In comparison, only 47% of individuals in the "slow" palatal expansion subgroup achieved such a change. Conversely, one individual in the "rapid" subgroup had a negative change in PT_{HOR} compared to three in the "slow" palatal expansion subgroup. Haas found the advancement of the cephalometric "A" point is most pronounced when Class III elastics are employed post-expansion (15). Admittedly, other changes secondary to palatal expansion, including an increased mandibular plane angulation with concomitant backward rotation of the mandible, might also help correct a pseudo-Class III anterior crossbite.

Regarding changes in the maxilla, as referenced by the SN-PP and FH-PP angulations, translocation was on average in parallel to its original position for all expansion pace subgroup. This is in accord with the previous literature (11,13,14). Nevertheless, wide variations in the individual responses makes generalizations to the individual case impractical. While it seemed logical that there should be a relation between changes in SN-PP and and FH-MP on the one hand, and between changes in SN-MP and FH-MP on the other hand, regression analyses (Table 3) produced very low correlations of determination. The mechanism by which tipping of the palatal plane occurs is, at best, obscure. Perhaps variable disruption of the articulations of the maxilla with the other bones of the facial skeleton accounts for this phenomenon.

Somewhat surprisingly, the opening of the mandibular plane angle was not large overall, being merely 1.8° and 1.7° respectively relative to the SN and FH planes. The mandibular plane opening was not greatly affected by the pace of palatal expansion (Table 2). Increases in the mandibular plane angulation consequent to palatal expansion had been emphasized previously (8,11,14,15).

Conclusions

This study indicates that the best plane to reference linear changes in the cephalometric "A" point is the FH. It confirms earlier reports that there is an average downward and forward movement of point "A" during palatal expansion, with the greatest translocation occurring with rapid rather than slow activation. Changes in the position of the cephalometric "A" point of a magnitude considered clinically important were found in more than two-thirds of patients that underwent rapid palatal expansion, but in less than half of patients in the subgroup who received relatively slow palatal expansion therapy.

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POLOŽAJ KEFALOMETRIJSKE TOČKE "A" NAKON ŠIRENJA NEPCA

Sažetak

Širenje nepca koristi se u terapji uskih maksilarnih lukova udruženih sa jednostranim ili obostranim križnim zagrizom. Cilj je ovog ispitivanja bio utvrditi djelovanje takvog tretmana na točku "A".

Laterolateralni rendgenkefalogrami devedeset i šest pacijenata gdje je širenje nepce bi prvi ortodontski zahvat analizirani su prije i poslije tretmana. Vertikalni pomaci točke "A" promatran je u odnosu na vertiklanu udaljenost od Frankfurtske horizontale do prednje kranijalne baze (sela -nasion). Horizontalni pomak točke "A" mjeren je paralelno s Frankfurtskom horizontalom od tangente stražnjeg ruba pterigomaksilarne fisure i paralelno s prednjom kranijalnom bazom od točke sela. Podgrupe "forsirano" i "sporo" širenje nepca također su međusobno uspoređene.

Točka "A" značajno se pomiče prema dolje i prema naprijed, s tim da je pomak značajniji u grupi s forsiranim širenjem.

Vertikalni pomak u značajnoj je vezi s brzinom širenja nepca (p<0,1). Horizontalna komponenta pomaka prosječno je za više od 1 mm veća kod fosriranog nego kod sporog širenja; statistička značaj-

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nost nije pronađena. Povećanje inklinacije mandibularne ravnine iznosilo je od 1,4° do 2,0°.

Širenje nepca je povezano s pomakom točke "A" prema dolje i prema naprijed koje je veće kod pacijenata gdje se nepce forsirano širilo.

Ključne riječi: *kefalometrija, ortodontska terapija, širenje nepca.*

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