Raščlamba pomaka zuba nastalih djelovanjem aktivnih ploča

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Sažetak

Za distalni pomak molara upotrebljavaju se mnoge naprave: različite modifikacije aktivnih ploča, Headgear, magneti, superelastične NiTi opruge i omče itd.

Svrha je ovog istraživanja analizirati zubne pomake s pomoću elektronskoga računala koji nastaju djelovanjem aktivnih ploča s jednostranim ili obostranim vijcima za distalizaciju na modelima s drugim trajnim molarima ili bez njih.

Eksperimentalni postupak podijeljen je u 4 odvojena eksperimenta, ovisno o tome jesu li postojali drugi molari te o aktivaciji vijka jednostrano ili obostrano.

Aktivacijom ploče za jednostranu ili obostranu distalizaciju molara uz postojeće prve molare pokazuje da je moguće provesti distalizaciju prvih molara dok drugih molara još nema, no s negativnim popratnim učincima kao što su protruzija fronte, ali i mezijalni pomak očnjaka.

Aktivacijom ploče za jednostranu ili obostranu distalizaciju molara uz postojeće prve i druge molare pokazuje da se prvi i drugi molari odjednom ne mogu i ne smiju distalizirati pločama, jer su jedini pravi pomaci samo reaktivni - dakle, protruzija fronte i očnjaka, te izrazito i nekontrolirano bukalno naginjanje molara.

Ključne riječi: *aktivna ploča, distalizacija*

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Ortodontske naprave koje uzrokuju distalne pomake prvih molara i bukalnih segmenata upotrebljavaju se već više od jednoga stoljeća. Još je Angle opisao uporabu okcipitalnog sidrišta u terapiji maksilarne protruzije (1).

Mobilne se ortodontske naprave vrlo često primjenjuju za distalizaciju molara, premda mnogi autori navode i uporabu Headgeara u kombinaciji s takvom napravom (1-4).

Iako se molari mogu distalizirati u svakoj životnoj dobi, najbolji se učinak postiže u doba mješovite denticije, prije nicanja drugih molara, a najbolje je upotrijebiti kontinuiranu silu (5).

Mnogobrojne se naprave upotrebljavaju kako bi se distalizirali molari: mobilne naprave, Headgear, Pendulum naprava, magneti, superelastične NiTi opruge ili omče itd. (6-13).

Glavne prednosti koje bi trebala imati naprava za distalizaciju molara jesu: da pacijent bar minimalno surađuje i da prihvati samu napravu, zatim jednostavnost izrade, te jednostavna aktivacija (14).

Kao glavni problem prigodom distalnoga pomaka molara javlja se gubitak sidrišta koji uzrokuje povećanja incizalne stepenice (15).

Svrha je ovog istraživanja raščlamba zubnih pomaka s pomoću elektronskoga računala koji nastaju prigodom djelovanja aktivnih ploča s jednostranim ili obostranim vijcima za distalizaciju na modelima s drugim trajnim molarima ili bez njih.

Uzorak i postupci

Eksperimenti su provedeni na osobnom računalu karakteristika 64Mb RAM, 350 MHz, 8,4 GB Hdd, SVGA monitor 1024*768 uz namjensku programsku podršku koja je kreirana za ovo istraživanje u suradnji sa zagrebačkom tvrtkom VAMS. Sustavu je uz standardnu grafičku karticu pridodana i videokartica (frame grabber) Imascan - Imagraph.

Istraživanje je provedeno na modelu gornje čeljusti s pomičnim zubima - modificiranom typodontu.

Kao što je spomenuto, pomaci pojedinih zuba moraju se registrirati vrlo precizno, pa su zbog toga na zube urezane referentne točke i to po dvije na svakome zubu na granicama mezioaproksimalnih i distoaproksimalnih ploha s okluzalnom plohom ili incizalnim bridom u razini kontaktne točke. Njihovim spajanjem dobiven je određeni oblik konture zubnoga luka karakterističan za pripremljeni model. Taj se je oblik nakon izvršenih aktiviranja naprave, te mjerenja pomaka zuba djelovanjem pojedine aktivne ploče, mogao ponoviti s pomoću ključa načinjenog od elastomera.

Spajanjem ovih točaka formirano je 12 varijabla:

7+7 D - spojnica distalnih točaka na okluzalnoj plohi drugih kutnjaka

7+7 M - spojnica mezijalnih točaka na okluzalnoj plohi drugih kutnjaka

6+6 D - spojnica distalnih točaka na okluzalnoj plohi prvih kutnjaka

6+6 M - spojnica mezijalnih točaka na okluzalnoj plohi prvih kutnjaka

5+5 D - spojnica distalnih točaka na okluzalnoj plohi drugih pretkutnjaka

5+5 M - spojnica mezijalnih točaka na okluzalnoj plohi drugih pretkutnjaka

4+4 D - spojnica distalnih točaka na okluzalnoj plohi prvih pretkutnjaka

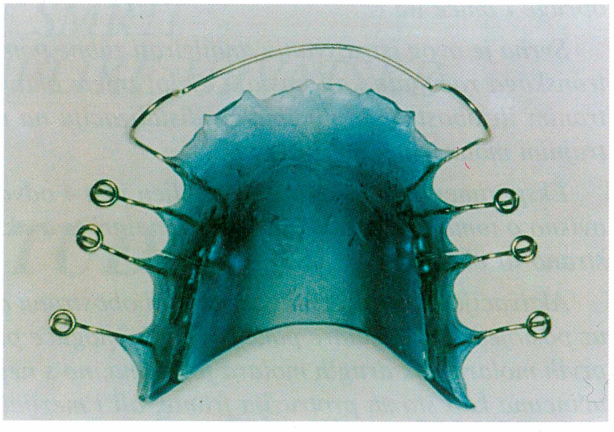
4+4 M - spojnica mezijalnih točaka na okluzalnoj plohi prvih pretkutnjaka

3+3 D - spojnica distalnih točaka očnjaka

3+3 M - spojnica mezijalnih točaka očnjaka

DUŽINA 6+6 - okomica sa spojnice incizalnih bridova središnjih sjekutića na dužinu 6+6 D

DUŽINA 7+7 - okomica sa spojnice incizalnih bridova središnjih sjekutića na dužinu 7+7 D



Slika 1. *Modificirana aktivna ploča za distalizaciju molara*
Figure 1. *Modified active plate for distalization of molars*

Eksperimentalni je postupak podijeljen u 4 odvojena eksperimenta, ovisno o tome jesu li postojali drugi molari, te o aktivaciji vijka jednostrano ili obostrano:

1. eksperiment: obostrana aktivacija ploče za distalizaciju molara, postoje prvi molari;
2. eksperiment: jednostrana aktivacija ploče za distalizaciju molara, postoje prvi molari;
3. eksperiment: obostrana aktivacija ploče za distalizaciju molara, postoje prvi i drugi molari;
4. eksperiment: jednostrana aktivacija ploče za distalizaciju molara, postoje prvi i drugi molari.

Za sve navedene eksperimente mjerenja su provedena po četri puta, svaki put nakon deset okretaja vijka.

Rezultati

U Tablici 1 i Slici 2 prikazani su rezultati prvog eksperimenta u kojem je raščlanjeno obostrano dje-

Tablica 1. *Pojedinačni transverzalni pomaci referentnih točaka uzrokovani djelovanjem aktivne ploče s vijcima za obostranu distalizaciju molara, uz postojeće prve molare*

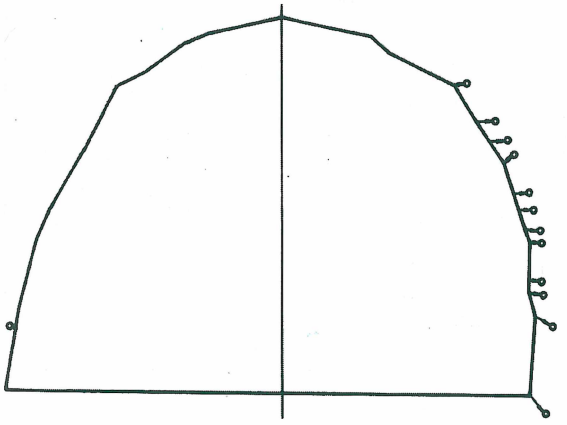
Table 1. *Some transversal movements of referent points, caused by the effect of an active plate with screws for bilateral distalization of molars, with first molars present*

	I	II	III	IV
6+6 D	0.61	0.61	0.62	0.31
6+6 M	1.23	0.61	1.23	-0.31
5+5 D	0.93	-0.32	0.61	0.31
5+5 M	0.92	0.30	0.00	0.62
4+4 D	1.23	-0.30	0.30	-0.31
4+4 M	0.31	0.00	0.31	0.00
3+3 D	1.12	0.00	0.00	0.31
3+3 M	0.61	0.32	0.31	-0.61
DUŽ. 6+6	1.57	0.68	1.35	-0.23

Tablica 2. *Pojedinačni transverzalni pomaci referentnih točaka uzrokovani djelovanjem aktivne ploče s vijkom za jednostranu distalizaciju molara, uz postojeće prve molare*

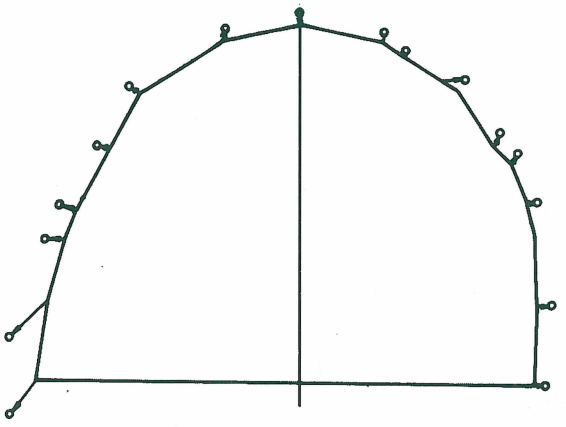
Table 2. *Some transveral movements of referent points, caused by the effect of an active plate with screws for unilateral distalization of molars, with first molars present*

	I	II	III	IV
6+6 D	0.30	1.24	0.03	-0.26
6+6 M	0.92	1.54	0.64	-0.28
5+5 D	0.62	0.00	0.31	-0.85
5+5 M	0.61	0.31	0.00	-0.53
4+4 D	0.62	0.31	-0.30	-0.21
4+4 M	0.61	0.00	-0.31	-0.15
3+3 D	0.62	0.00	0.00	-0.42
3+3 M	0.00	0.31	0.00	-0.36
DUŽ. 6+6	1.35	0.50	0.22	-0.42



Slika 2. *Promjene konture zubnoga luka nastale djelovanjem aktivne ploče s vijcima za obostranu distalizaciju molara, uz postojeće prve molare.*

Figure 2. *Changes in the contour of the dental arch caused by the effect of the active plate with screws for bilateral distalization of molars, with first molars present.*



Slika 3. *Promjene konture zubnoga luka nastale djelovanjem aktivne ploče s vijkom za jednostranu distalizaciju molara, uz postojeće prve molare.*

Figure 3. *Changes in the contour of the dental arch caused by the effect of the active plate with screws for unilateral distalization of molars, with first molars present.*

lovanje aktivne ploče s ugrađenim vijcima za distalizaciju molara na modelu na kojem su bili prisutni samo prvi molari. Uočljivo je da, kada bi se aktivirala sva četiri vijka, nastaje ravnomjeran distalni pomak prvih molara. Frontalni su zubi, uključujući i očnjake, za gotovo jednak iznos protrudirani. Uočljiv je i nešto manji bukalni pomak premolara, ali i distaliziranih molara.

U Tablici 2 i Slici 3 prikazani su rezultati drugog eksperimenta u kojem je raščlanjeno jednostrano djelovanje aktivne ploče s ugrađenim vijkom za distalizaciju molara na modelu na kojem su bili samo prvi molari. Registriran je izrazit distalni te nešto manji bukalni pomak distaliziranog prvog molara. Nije zabilježen gotovo nikakav pomak molara kontralateralne strane. Sjekutići, očnjak i premolari kontralateralne strane, dakle zubi, dijagonalno, transverzalno od vijka, uočljivo su protrudirani, odnosno pomaknuti bukalno. Zanimljivi su pomaci pretkutnjaka u sagitalnoj ravnini. Nakon prve tri aktivacije oni se pomiču suprotno od pomaka molara, a nakon posljednje aktivacije i oni su bili pomaknuti malo ali ipak uočljivo distalno.

Treći je eksperiment prikazan u Tablici 3 i Slici 4. Registrirani su pomaci zuba koji nastaju obostranom aktivacijom ploče za distalizaciju molara, ali uz postojanje i prvih i drugih molara. Sva četiri molara ravnomjerno se pomiču distalno i nešto manje bukalno, no bukalni je pomak nešto jače izražen na drugim molarima. Bukalni pomak premolara, odnosno protruzija frontalnih zuba, ravnomjerni su na cijelome zubnom luku. Premolari nisu pomaknuti u sagitalnoj ravnini, ali su zato svi frontalni zubi protrudirani, čak za veće iznose nego što su molari distalizirani.

Četvrti je eksperiment prikazan u Tablici 4 i Slici 5. Jednostranim djelovanjem ploče za distalizaciju

Tablica 3. *Pojedinačni transverzalni pomaci referentnih točaka uzrokovani djelovanjem aktivne ploče s vijcima za obostranu distalizaciju molara, uz postojeće druge molare*

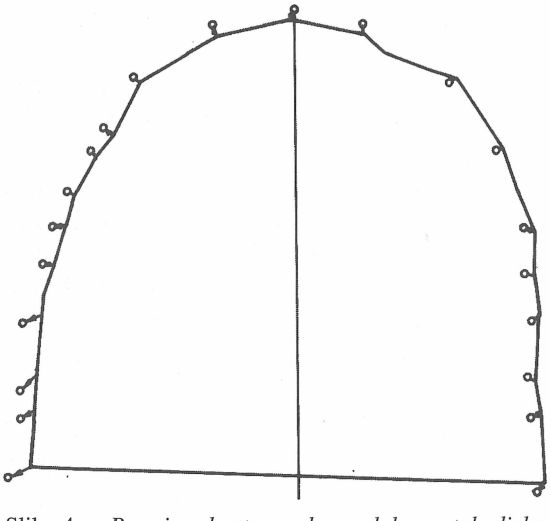
Table 3. *Some transversal movements of referent points, caused by the effect of an active plate with screws for bilateral distalization of molars, with second molars present*

	I	II	III	IV
7+7 D	0.63	0.06	0.88	0.64
7+7 M	0.94	0.39	0.86	0.32
6+6 D	0.62	0.71	0.55	0.63
6+6 M	0.93	0.40	1.17	0.62
5+5 D	0.63	0.09	0.85	0.32
5+5 M	0.94	0.09	0.85	0.00
4+4 D	0.31	0.42	0.21	-0.32
4+4 M	0.62	-0.19	0.19	-0.32
3+3 D	0.63	-0.18	0.80	0.00
3+3 M	0.31	0.17	0.14	0.32
DUŽ. 7+7	0.46	1.61	0.91	1.14

Tablica 4. *Pojedinačni transverzalni pomaci referentnih točaka uzrokovani djelovanjem aktivne ploče s vijkom za jednostranu distalizaciju molara, uz postojeće druge molare*

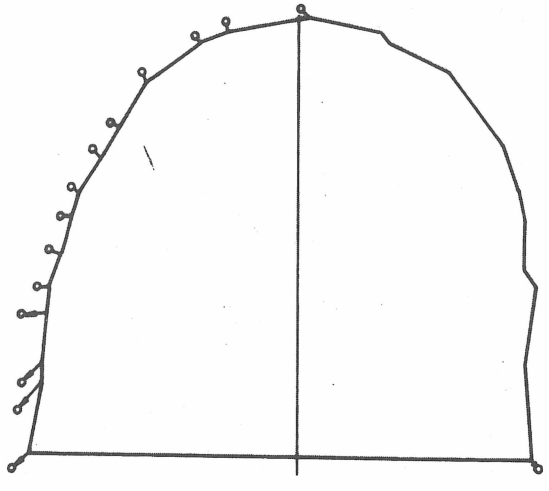
Table 4. *Some transversal movements of referent points, caused by the effect of an active plate with screws for unilateral distalization of molars, with second molars present*

	I	II	III	IV
7+7 D	0.07	0.86	0.25	0.01
7+7 M	1.02	0.23	-0.03	0.95
6+6 D	-0.23	0.86	-0.04	0.35
6+6 M	0.70	0.55	-0.03	0.98
5+5 D	0.41	0.22	-0.34	0.00
5+5 M	0.72	0.23	-0.02	0.00
4+4 D	0.42	-0.09	-0.32	0.00
4+4 M	0.12	0.19	-0.28	-0.31
3+3 D	0.14	0.18	-0.26	0.30
3+3 M	0.17	0.15	-0.22	0.62
DUŽ. 7+7	0.02	0.66	0.37	0.00



Slika 4. *Promjene konture zubnoga luka nastale djelovanjem aktivne ploče s vijcima za obostranu distalizaciju molara, uz postojeće druge molare*

Figure 4. *Changes in the contour of the dental arch caused by the effect of the active plate with screws for bilateral distalization of molars, with second molars present*



Slika 5. *Promjene konture zubnoga luka nastale djelovanjem aktivne ploče s vijkom za jednostranu distalizaciju molara, uz postojeće druge molare*

Figure 5. *Changes in the contour of the dental arch caused by the effect of the active plate with screws for unilateral distalization of molars, with second molars present*

molara postojanje svih četiriju molara dobiveni su sljedeći rezultati. Zamjetan je distalni, ali i gotovo jednako izraženi bukalni pomak distaliziranog molara. Zanimljivo je da zubi kontralateralne strane nisu pomaknuti ni u kojem smjeru. Izuzetak je centralni sjekutić koji je protrudiran. Zubi na strani distalizacije vrlo su uočljivo pomaknuti bukalno i mezijalno (premolari i očnjak), odnosno protrudirani (sjekutići).

Rasprava

Rezultate provedenog istraživanja vrlo je teško usporediti s rezultatima drugih autora zbog toga što je u literaturi opisana uglavnom upotreba računala u rendgenkefalometriji i gnatometrijskim istraživanjima izravno na modelima (16-20).

Biomehaničke raščlambe djelovanja ortodontskih naprava uglavnom su se provodile metodama fotoelasticimetrije, holografske interferometrije, tenzitometrije i metodom konačnih elemenata. Vrlo su rijetka istraživanja *in vivo,* pa se mjerenja provode uglavnom na raznim modelima. Opće je prihvaćeno mišljenje da kakvoća modela ponajviše utječe na vrijednost rezultata, dakle - što vjerniji model to vjerniji rezultati (21-27).

Jedno od rijetkih biomehaničkih istraživanja na aktivnim pločama jest ono Pavlina koji na maceriranim lubanjama metodom holografske interferometrije utvrđuje distribuciju sila i naprezanja na bližim ali i udaljenim strukturama kraniofacijalnoga kompleksa za vrijeme djelovanja gornjih simetrično i asimetrično rezanih aktivnih ploča s ugrađenim vijkom za transverzalno širenje. Budući da autor utvrđuje naprezanja i deformacije na skeletu lubanje, njegovo istraživanje, premda vrlo zanimljivo, nije za usporedbu s provedenim istraživanjem (28), osim što konstatira veće pomake na strani naprave s manjom aktivnom površinom, što se potpuno slaže s ovdje prikazanim rezultatima.

Nalazi Perkovića provedeni na vrlo sličan način, na istome modelu, potpuno potvrđuju činjenicu da se na strani mobilne ortodontske naprave s ukupnom manjom aktivnom površinom mogu registrirati veći pomaci koji su vjerojatno posljedica većih sila (29).

Za distalizaciju molara mogu se primijeniti mnoge naprave. One se razlikuju po svojoj konstrukciji, ali i po načinu djelovanja.

Vjerojatno najčešće upotrebljavana naprava jest Headgear, ali i ona ima negativnih učinaka na profil lica te rotacijski smjer rasta, a najveći je problem često loša suradnja (15,30).

Kao jedna od mogućnosti za distalizaciju molara mogu se uporabiti i statički magneti. Oni distaliziraju molare vrlo učinkovito i to tako da ih translatorno pomiču, a sidrište se pojačava konvencionalnim tehnikama.

Kao jedna od prednosti magneta navodi se povećan stupanj osteogeneze i remodelacija kosti koja ovisi o ispravnom doziranju sile (6). Problem sidrišta koji je moguće riješiti samo pojačanjem, dakle uporabom dodatnih naprava ponovno u prvi plan dovodi utjecaj pacijentove suradnje.

Ghosh i Nanda (14) u svojem istraživanju analiziraju učinak Pendulum naprave na distalizaciju gornjih molara, te recipročan učinak na premolare i sjekutiće, što su kefalometrijski analizirali. Srednja vrijednost iznosa distalizacije molara iznosila je 3,37 mm, s distalnim nagnućem od 8,36°. Mezijalni pomak prvih premolara bio je 2,55 mm, a slično kao i u ovom istraživanju povećala se je transverzalna širina između meziobukalnih kvržica molara. U svojem istraživanju autori nalaze i distalizaciju maksilarnih drugih molara u iznosu od 2,27 mm, što je terapijski svakako povoljnije nego prigodom djelovanja ploča.

Jones jig naprava je koja se može upotrijebiti i za distalizaciju molara, a ima intraoralno uporište, što eliminira potrebu za pacijentovom suradnjom. Runge, Martin i Bukai (7) analiziraju djelovanje te naprave te nakon kefalometrijske raščlambe zaključuju da su znatno povećani sljedeći parametri: distalni pomak maksilarnih molara, mezijalni pomak premolara kao sidrišne jedinice, te mezijalni pomak maksilarnih sjekutića. Gubitak sidrišta, koji se očituje protruzijom sjekutića, negativan je učinak tretmana, koji nalazimo i u ovome istraživnju.

Johnson (8) u svojemu radu izvješćuje o obostranom distalnom pomaku maksilarnih molara u korekciji dentalne Klase II koristeći se kombinacijom aktivne ploče i cervikalnog Headgeara. Ta kombinacija dovodi do distalnoga translatornog pomaka molara, te se zato može upotrijebiti za produženje dužine maksilarnog luka. Ovakva je terapija je za pacijenta sigurno zahtjevnija nego kad se provodi samo Headgearom, pa se ponovno postavlja pitanje suradnje.

Jedna od novijih metoda u distalizaciji molara služi se i NiTi oprugama ili omčama, koji se aktiviraju za 1mm na mjesec proizvodeći silu od 100 gr. Kako je negativna strana ove distalizacije gubitak sidrišta uz posljedično povećanje incizalne stepenice, preporučuje se upotrijebiti modificiranu Nanceovu napravu za pojačanje sidrišta. Dakle, negativni učinci su slični kao kod vlastitog istraživanja (31).

Iz gore navedenog vidljivo je da se za distalizaciju molara rabe mnoge konstrukcije naprava, a odabir im najčešće ovisi u umješnosti i mogućnostima terapeuta te pacijentovoj suradnji.

Raščlamba rezultata vlastitih eksperimenata zahtijeva isticanje i komentar nekih detalja. Prva dva eksperimenta pokazuju da je moguće provesti na prvi pogled uspješnu distalizaciju prvih molara dok drugih molara još nema. No popratni učinci nastali zapravo zbog nedovoljnog sidrišta možda su ipak prevelika žrtva. Protruzija fronte, koja je najuočljivija, može se poslije možda korigirati, ali mezijalni pomak očnjaka poslije je najčešće razlog za dugotrajnu, često i ekstrakcijsku terapiju. Kako je cilj distalizacije molara zapravo, pokušaj da se izbjegne ekstrakcija premolara, očigledno je da je u takvu slučaju cijela prva faza, dakle distalizacija, samo gubitak vremena. Distalizacija gornjih molara najčešće se provodi kod posljedica preranog gubitka i posljedične sekundarne kompresije. Kako su očnjaci već u Klasi II zbog mezijalnog pomaka, u takvim je slučajevima njihov dodatni mezijalni pomak uzrokom još težih posljedica od gore opisanih.

Druga dva eksperimenta bez sumnje pokazuju da se prvi i drugi molari odjednom ne mogu i ne smiju distalizirati pločama, jer su jedini pravi pomaci samo reaktivni - dakle, protruzija fronte i očnjaka, te izrazito i nekontrolirano bukalno naginjanje molara.

Zaključci

Na temelju provedenog istraživanja možemo zaključiti sljedeće:

- Aktivacijom ploče za jednostranu ili obostranu distalizaciju molara uz postojeće prve molare pokazuje da je moguće provesti distalizaciju prvih molara dok drugih molara još nema, no s negativnim popratnim učincima kao što su protruzija fronte, ali i mezijalni pomak očnjaka.
- Aktivacijom ploče za jednostranu ili obostranu distalizaciju molara uz postojeće prve i druge molare pokazuje da se prvi i drugi molari odjednom ne mogu i ne smiju distalizirati pločama jer su jedini pravi pomaci samo reaktivni - dakle protruzija fronte i očnjaka, te izrazito i nekontrolirano bukalno naginjanje molara.

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Analysis of Tooth Movement Caused by the Effect of Active Plates

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Summary

Numerous appliances are used for distal movement of molars: different modifications of active plates, Headgear, magnets, super-elastic NiTi springs and loops etc.

The aim of this investigation was to use an electronic computer to analyse the movement of teeth, which occur during the effect of active plates with unilateral and bilateral screws for distalization on models, with or without second permanent molars.

The method was divided into four separate experiments, depending on whether the second molars were present and whether activation of the screw was unilateral or bilateral.

Activation of the plate for unilateral or bilateral distalization of molars with first molars present demonstrated that it is possible to carry out distalization of first molars while second molars are still not present, although with negative accompanying effects such as: protrusion of the frontal teeth and messial movement of canines.

Activation of a plate for unilateral or bilateral distalization of molars with first and second molars present demonstrated that the first and second molars cannot, and must not, be distalized by plates at the same time, because the only real movements are reactive, i.e. protrusion of frontal teeth and canine, and marked and uncontrolled buccal inclination of molars.

Key words: *active plate, distalization*

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Orthodontic appliances which lead to distal movements of the first olars and buccal segments have been used for more than a century. Angle described the use of occipital anchorage in the treatment of maxillary protrusion (1).

Mobile orthodontic appliances are frequently used for distalization of molars, although many authors report the use of Headgear in combination with such an appliance (1-4).

Although molars can be distalized at any age, the best effect is achieved at the age of mixed dentition, before the eruption of second molars, and it is best to apply continued force (5).

Numerous appliances are used to distalize molars: mobile appliances, Headgear, Pendulum appliance, magnets, super-elastic NiTi springs or loops etc. (6-13).

The main priorities of appliances for distalization of molars are minimal patient co-operation and

his acceptance of the apparatus, simple construction and activation (14).

The main problem during distal movement of the molar is loss of anchorages which leads to increased incisal step (15).

The aim of this investigation was to use an electronic computer to analyse tooth movement, during the effect of active plates with unilateral or bilateral screws for distalization on models with or without second permanent molars.

Sample and methods

The experiments were carried out on a personal computer with the following characteristics: 64Mb RAM, 350 MHz, 8.4 GB Hdd, SVGA monitor 1024*768 with a special programme control, which was created for this investigation in cooperation with the Zagreb firm VAMS. Besides a standard graphic map the system was also provided with a video map (frame grabber) Imascan - Imagraph.

The investigation was carried out on a model of the upper jaw with moveable teeth - modified typodont.

As previously mentioned the movement of individual teeth must be accurately registered, and therefore two referent points were marked on each tooth on the borders of the mesio-approximal and disto-approximal surfaces with occlusal surface, or the incisal edge at the level of the contact points. Their joining results in the formation of a particular contour of the dental arch, which is characteristic for the prepared model. After activation of the apparatus and measuring tooth movement caused by the effect of active plates, the form can be repeated by means of a key made of elastomer.

By joining these points 12 variables are formed:

7+7 D - junction of distal points on the occlusal surface of second molars

7+7 M - junction of messial points on the occlusal surface of second molars

6+6 D - junction of distal points on the occlusal surface of first molars

6+6 M - junction of messial points on the occlusal surface of first molars

5+5 D - junction of distal points on the occlusal surface of second molars

5+5 M - junction of messial points on the occlusal surface of second molars

4+4 D - junction of distal points on the occlusal surface of first pretmolars

4+4 M - junction of messial points on the occlusal surface of first pretmolars

3+3 D - junction of distal points of canines

3+3 M - junction of messial points of canines

LENGTH 6+6 - Vertical line with junctions of incisal edges of the central incisors to length 6+6 D

LENGTH 7+7 - Vertical line with junctions of incisal edges of the central incisors to length 7+7 D

The method was divided into four separate experiments, depending on whether there were second molars present and on unilateral or bilateral activation of the screw:

1. Experiment: bilateral activation of the plate for distalization of molars, first molars present.
2. Experiment: unilateral activation of the plate for distalization of molars, first molars present.
3. Experiment: bilateral activation of the plate for distalization of molars, first and second molars present.
4. Experiment: unilateral activation of the plate for distalization of molars, first and second molars present.

Measurements were taken on four occasions, each time after ten turns of the screw.

Results

Table 1 and Fig. 2 present the results of the first experiment in which the bilateral effect of the active plates with incorporated screws for distalization of molars was analyzed on a model on which only the first molars were present. During the four activations of the screws uniform distal movement of the first molars occurred. The frontal teeth, including the canines, protruded by almost the same amount. Slightly less buccal movement was seen for the premolars and also for the distalized molars.

Table 2 and Fig. 3 present the results of the second experiment in which the unilateral effect of the active plate with incorporated screw for distalization of molars was analyzed on a model on which only the first molars were present. Marked distal and

somewhat less buccal movement was registered on the distalized first molar. Almost no movement was registered of the molars on the contralateral side. The incisors, canine and premolars of the contralateral side protruded diagonally, transversally from the screw, i.e. were buccally moved. Movements of the premolars in the saggital plane were interesting. Namely, after the first three activations they moved in an opposite direction to the movement of the molars, and after the last activation they were also moved slightly distally.

The third experiment is presented in Table 3 and Fig. 4. Movements of teeth were registered, resulting from bilateral activation of the plate for distalization of molars, with the presence of the first and second molars. All four molars moved distally for the same amount and moved slightly less buccally. The buccal movement was somewhat more marked on the second molars. Buccal movement of the premolars, i.e. protrusion of the frontal teeth, was uniform on the whole of the dental arch. The premolars did not move in the saggital plane, although all the frontal teeth protruded even more than the amount the molars had been distalized.

Table 4 and Fig. 5 shows the results of the fourth experiment. The following results were obtained by unilateral effect of the plate for distalization of molars, with all four molars present. Distal, and almost uniform, marked buccal movement of the distalized molar was seen. It was interesting to note that the teeth of the contralateral side were not moved in any direction, with the exception of the central incisor, which protruded. The teeth on the side of the distalization were moved buccally and mesially (premolars and canine), or protruded (incisors).

Discussion

The results of this investigation are difficult to compare with those of other authors, due to the fact that literature mainly describes the use of an electronic computer in roentgencephalometry and gnathometric studies directly on models (16-20).

Biomechanical analyses of the effect of orthodontic appliances are usually performed by methods of photo-elasticimetry, holographic interferometry, tensitometry and the method of finite elements. Investigations in vivo are very rare, and thus measuring is carried out mainly on different models. It is generally accepted that the quality of the model has most influence on the value of the results, thus the accuracy of the results depends on the accuracy of the model (21-27).

One of the rare biomechanical investigations on active plates was that of Pavlin, who used a method of holographic interferometry on macerated skulls to determine the distribution of forces and stress on near and distant structures of the craniofacial complex during the effect of upper symmetrically and asymmetrically cut active plates with incorporated screw for transversal expansion. As the author confirmed stress and deformations on the skull, his investigation, although very interesting, cannot be compared with the present investigation (28) apart from his conclusion of greater movement on the side of the appliance with less active surface, which completely agrees with the results presented here.

The findings of Perković, on the same model and performed in a very similar manner, fully confirm the fact that on the side of mobile orthodontic appliances with a less active surface, greater movements can be registered which are most likely the result of greater forces (29).

Numerous appliances can be used for distalization of molars, which differ according to their construction and effect.

Probably the most frequently used appliance is Headgear, although it also has negative effects on the facial profile and rotational direction of growth, and the greatest problem is often poor cooperation (15,30).

Static magnets can also be used for distalization of molars. They distalize molars very effectively in such a way that they are moved translaterally while the anchorage is reinforced by conventional techniques.

One of the advantages of magnets is reported to be the increased degree of osteogenesis and remodelling of bone, which depends on the correct amount of force (6). The problem of the anchor/anchorage, which can only be solved by reinforcement, i.e. the introduction of additional appliances, again raises the question of patient co-operation.

In their investigation Ghosh and Nanda (14) analysed the effect of Pendulum appliance on distaliza-

tion of the upper molars, and the reciprocal effect on premolars and incisors, which were cephalometrically analysed. The mean value of the amount of distalization of molars was 3.37 mm, with distal inclination of 8.36°. The messial movement of the first premolars amounted to 2.55 mm, and as in the present investigation increased transversal expansion occurred between the messiobuccal cusps of the molars. The authors also found distalization of maxillary second molars amounting to 2.27 mm, which is therapeutically much more satisfactory than during the effect of a plate.

Jones jig is an appliance which can be used for distalization of molars. It has an intraoral base, which eliminates the need for patient cooperation. Runge, Martin and Bukai (7) analysed the effect of this appliance and after cephalometric analysis concluded that the following parameters were significantly increased: distal movement of maxillary molars, messial movement of premolars as anchor/anchorage units and messial movement of maxillary incisors. Loss of anchorage, which can be seen with the protrusion of incisors, is a negative effect of the treatment, which we also found in our investigation.

Johnson (8) reported bilateral distal movement of maxillary molars during correction of dental Class II, using a combination of active plate and cervical Headgear. This combination leads to distal translateral movement of molars, and as such can be used for lengthening the maxillary arch. For the patient such therapy is more demanding than when only Headgear is used, and thus the question of co-operation is again raised.

One of the latest methods for distalization of molars uses NiTi springs or loops, which are activated by 1 mm a month, producing a force of 100 gr. However, a negative effect of this distalization is loss of anchors/anchorages, with a consequent increase in the incisal step, use of a modified Nance appliance is recommended for reinforcing the anchorages. Thus the negative effects are similar to those in our investigation (31).

From the above it can be seen that numerous constructed appliances are used for distalization of molars, and their choice most often depends on the skill and possibilities of the therapist, and also patient cooperation.

Analysis of the results of our experiments require emphasis and comment on some details. The first two experiments demonstrate that it is possible to perform apparently successful distalization of first molars, while second molars are still not present. However, the accompanying effects which occur because of the inadequate anchor/anchorage are possibly too great a sacrifice. Protrusion of the frontal teeth which is most obvious, can possibly later be corrected, although the messial movement of the canine is later the most frequent reason for lengthy therapy and often extraction. As the object of distalization of molars is in fact an attempt to avoid extraction of premolars, clearly in such a case the whole of the first phase, i.e. distalization, is merely a waste of time. Distalization of upper molars is most often performed in the case of premature loss and consequent secondary compression. As canines are already in class II because of messial movement, in such cases their additional messial movement leads to even more serious consequences than those described above.

The second two experiments demonstrate that the first and second molars cannot, and must not, be distalized by plates at the same time, as the only real movements are reactive, i.e. protrusion of the frontal teeth and canines, and marked, uncontrolled buccal inclination of the molars.

Conclusions

Based on the results of the investigation the following can be concluded:

- Activation of a plate for unilateral or bilateral distalization of molars with the first molars present shows that it is possible to carry out distalization of the first molars while second molars are still not present, although with negative accompanying effects, such as: protrusion of the frontal teeth and also messial movement of canines.
- Activation of a plate for unilateral or bilateral distalization of molars with first and second molars indicates that the first and second molars together cannot, and must not, be distalized by plates, because the only real movements are reactive, i.e. protrusion of the frontal teeth and canines, and marked, uncontrolled buccal inclination of molars.