

Mogućnost tretmana impaktiranih zuba primjenom permanentnih magneta

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Sažetak

Tradicionalni kirurško-ortodontski tretman impaktiranih zuba ima i nedostataka, što potiče nova istraživanja te problematike.

Istraživanje je provedeno sa svrhom da bi se utvrdilo jesu li Sm - Co 5 magneti, dimenzija prikladnih za usnu šupljinu, dostatni izvori ekstruzijskih sila; zatim da bi se našli najbolji položaji magnetskih segmenata pri postupku, tretmana impaktiranog zuba; objektivizirao smjer kretanja zuba u postupku, i zaključilo o eventualnoj kliničkoj aplikabilnosti analiziranoga postupka.

Uzorak se je sastojao od 4 para magneta, valjkasta oblika, različitih dimenzija (4x4, 5x2, 5x4 i 5,85x6 mm) i volumena čije je magnetsko polje usmjereno usporedno s uzdužnom osi. Promjene intenziteta privlačnih sila unutar magnetskoga polja analizirana su dinamometrom u sklopu vlastite konstrukcije. Smjer pomicanja retiniranog zuba, u simuliranom postupku in vitro, promatran je na akrilnome modelu gornje čeljusti primjenom prirodnoga zuba s pričvršćenim unutrašnjim magnetom i konvencionalne ortodontske ploče kao nosača vanjskoga magneta.

Rezultati su pokazali da su izmjerene vrijednosti sila magneta prikladnih dimenzija, dostatne za ekstruziju impaktiranoga zuba. Intenzitet sila ovisi o udaljenosti magneta te onjegovim dimenzijama. Intenzitet privlačne sile pri povećanom razmaku magneta znatnije opada pri početnim manjim udaljenostima. Utvrđena su 4 osnovna položaja magneta, a smjer kretanja retiniranoga zuba unutar magnetskoga polja predvidljiv je u svakoj fazi postupka. Rezultati teoretskih spoznaja upućuju na kliničku aplikabilnost.

Ključne riječi: magneti, permanentni magneti, retinirani zubi, magnetske sile, ekstruzija zuba

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Uvod

Magneti se već dvadeset godina primjenjuju u ortodontskom liječenju, no na pojedine vrste anomalija razmjerno rijetko i ograničeno. Mogućnost primjene permanentnih magneta kao alternative tradicionalnim izvorištima aktivnih sila u ortodontici među prvima su objavili Kawata i Takeda (1), koristeći se njima kao zamjenom za bravice. Blechman (2), Gianelly et al. (3,4), Cozzani et al. (5), Cosentino i Amato (6) te Bondemark i Kurol (7) upotrebljavaju magnete u liječenju klase II. Tretman otvorenoga zagriža intruzijom lateralnih zuba opisali su Dellinger (8), Woods i Nanda (9) te Kiliaridis et al. (10). Mišolić (11) razmatra teoretske mogućnosti tretmana retiniranih zuba uporabom permanentnih magneta kao izvora ortodontskih sila.

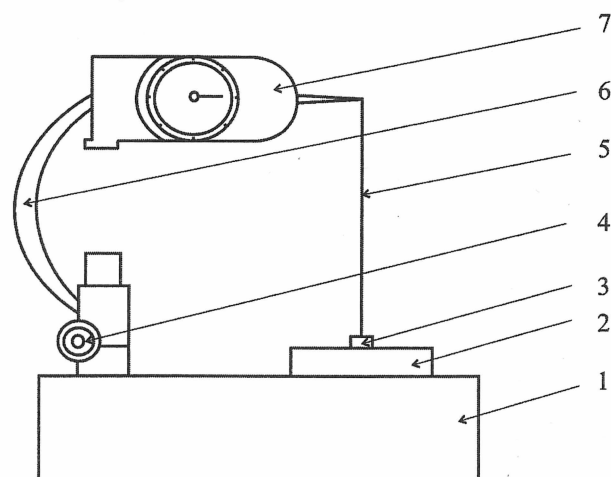
Problem tretmana retiniranih zuba oduvijek postoji u ortodontici, a postupci koji se pri tome primjenjuju pokazuju nedostatke i potiču na nova istraživanja.

Svrha istraživanja bila je utvrditi sljedeće: jesu li Sm - Co 5 (samarium-kobalt) magneti prikladnih dimenzija za uporabu u usnoj šupljini dostatan izvor ekstruzijskih sila; koji su optimalni položaji magnetskih segmenata da bi se postiglo pomicanje impaktiranoga zuba; objektivizirati smjerove željenih kretanja impaktiranoga zuba; na temelju provedenog eksperimenta zaključiti o kliničkoj primjenjivosti postupka.

Materijal i postupci

U eksperimentu su upotrebljena 4 para Sm - Co 5 magneta valjkasta oblika, (BH) max 28 MGOe (225 KJ/m³). Odabrani magneti dimenzija 4 x 4, 5 x 2, 5 x 4 i 5.85 x 6 mm glatko su polirani s usmjerenjem magnetskoga polja usporedno s visinskom osi.

Intenzitet privlačnih sila među magnetima mjerio se uporabom izvorne konstrukcije čiji je shematski prikaz protumačen u prilogu (Slika 1). Dinamometrom, koji je sastavni dio spomenute naprave, mjerile su se vrijednosti između parova magneta navedenih dimenzija i njihovih različitih kombinacija. Konstrukcija naprave omogućuje da se privlačne sile mjere na udaljenostima od 0,2 do 30 mm, u segmen-



Slika 1. Shematski prikaz i sastavnica naprave za mjerenje privlačnih magnetskih sila (1. postolje, 2. držač magneta, 3. magnet, 4. vijak opterećenja dinamometra, 5. spojna nit, 6. klizni nosač dinamometra, 7. dinamometar)

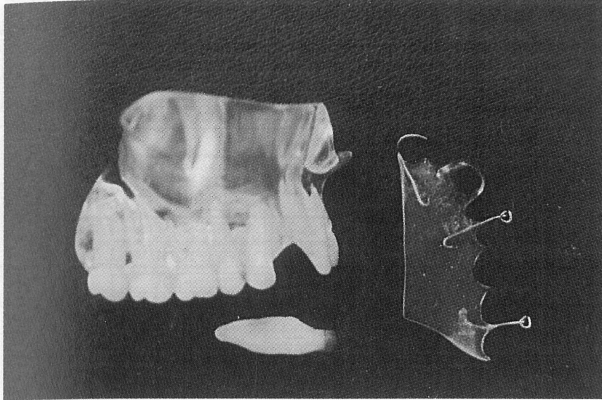
Figure 1 Synoptic presentation and component parts for measuring magnetic force (1. base, 2. magnet holder, 3. magnet, 4. screw for tightening the dynamometer, 5. connecting thread, 6. dynamometer carrier, 7. dynamometer)

tima od 0,20 mm, u trima različitim položajima: visinske su osi obaju magneta podudarne, visinske su osi inklinirane pod kutem od 10 stupnjeva, i visinske osi su inklinirane pod kutem od 20 stupnjeva.

Za potrebe eksperimanata, u kojem će se simulirati smjerovi pomaka impaktiranoga zuba, izrađen je akrilatni model desne polovine gornje čeljusti u prirodnoj veličini. Na vršak prirodnoga desnog očnjaka nalijepljen je Sm - Co 5 magnet veličine 5x4 mm (promjer x visina). Očnjak se u različitim položajima postavlja unutar predviđena prostora modela čeljusti, ispunjena gustim prozirnim vazelinom koji oponaša otpor prirodnoga tkiva kretanju zuba. Kao držač vanjskog magneta, istih dimenzija, služi odgovarajuća polovica standardne ortodontske ploče (Slike 2 i 3). Unutar tako postavljena magnetskog polja između obaju magneta, analizirat će se različitosti smjerova pomaka impaktiranoga zuba.

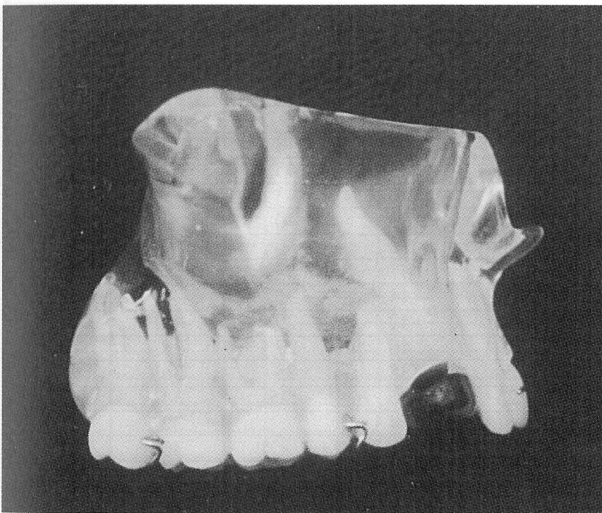
Rezultati

Promjene intenziteta sila unutar magnetskoga polja između različitih dimenzija magneta kao i triju njihovih različitih osovinskih usmjerenosti zabilje-



Slika 2. Akrilni model maksile, očnjak s apliciranim primarnim magnetom i retencijska ploča sa sekundarnim magnetom

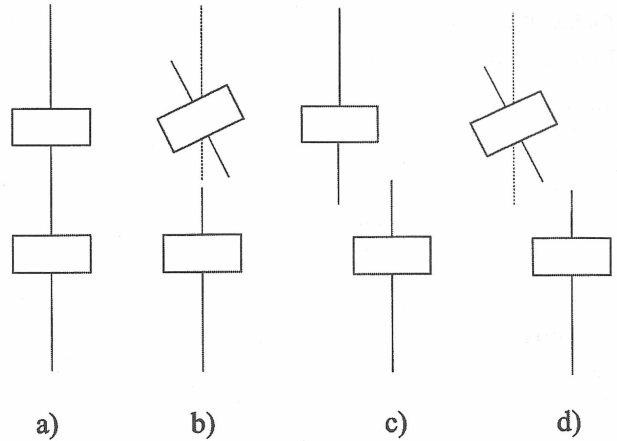
Figure 2 Acrylic model of the maxillary canine with applied primary magnet and retention plate with secondary magnet



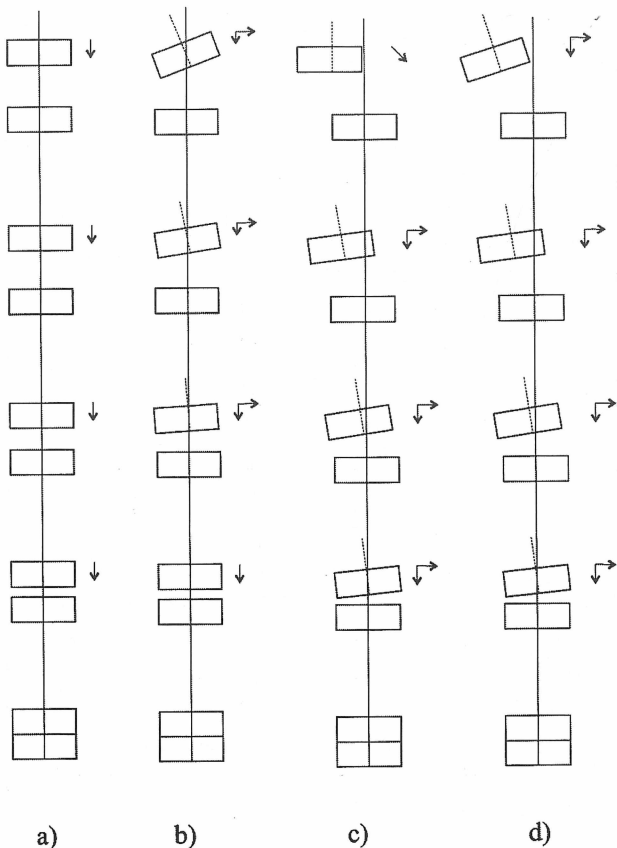
Slika 3. Jedan od analiziranih položaja retiniranoga zuba u uspostavljenom magnetskom polju

Figure 3 One of the analyzed positions of the impacted tooth in the set up magnetic field

žene su centi Newton jedinicama u Tablicama 1, 2 i 3. Iako je glavni objekt opažanja bio impaktirani zub, istraživanje je pokazalo da osnovnu ulogu u njegovu kretanju ima međusobni odnos magneta. Rezultati raščlambe smjerova kretanja impaktiranoga zuba pokazali su 4 osnovna međusobna položaja magneta (Slika 4). Bez obzira na početni položaj retiniranoga zuba u čeljusti, njegov se ishodišni položaj može svrstati u jedan od 4 spomenuta, te će



Slika 4. Osnovni međusobni položaji magneta
Figure 4 Basic mutual position of the magnet



Slika 5. Modeli simuliranoga kretanja retiniranoga zuba
Figure 5 Models of simulated movement of the impacted tooth

se njegov put, ovisno o odnosu magneta, odvijati prema jednom od 4 modela kretanja (Slika 5).

Tablica 1. Vrijednosti izmjerenih sila u centi Newton jedinicama primjenom različitih dimenzija magneta
 Table 1 Values of the measured forces in centi newton units with the application of different magnet dimensions

Udaljenost mjerenih magneta (mm) The distance between measured magnets (mm)	DIMENZIJE MJERENIH MAGNETA / THE DIMENSIONS OF MEASURED MAGNETS (promjer*visina u mm) / (dynamometer*height in mm)									
	4*4 4*4	5*2 5*2	5*4 5*4	5.85*6 5.85*6	4*4 5*2	4*4 5*4	4*4 5.85*6	5*2 5*4	5*2 5.85*6	5*4 5.85*6
0.2	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250
0.4	>250	>250	>250	>250	244	>250	>250	>250	>250	>250
0.6	245	245	>250	>250	220	>250	>250	>250	>250	>250
0.8	220	220	>250	>250	200	245	>250	>250	>250	>250
1.0	196	195	>250	>250	186	224	247	231	>250	>250
1.2	173	175	>250	>250	163	204	236	209	>250	>250
1.4	151	156	243	>250	146	182	220	189	236	>250
1.6	132	138	224	>250	128	160	204	172	214	>250
1.8	120	125	201	>250	114	144	183	155	198	>250
2.0	107	110	184	>250	106	135	167	140	181	235
2.2	98	98	168	>250	97	122	155	128	165	218
2.4	89	88	149	>250	88	111	142	118	152	198
2.6	80	81	140	245	81	101	131	106	139	181
2.8	74	73	129	229	75	93	123	98	125	173
3.0	68	66	118	215	68	85	113	90	117	159
3.2	62	61	110	196	63	77	104	84	109	147
3.4	57	56	100	185	57	71	97	77	100	137
3.6	52	52	93	172	51	66	90	70	93	127
3.8	47	48	86	161	46	61	84	64	88	117
4.0	44	44	81	150	44	57	79	60	81	107
4.2	41	41	75	140	41	53	73	56	75	99
4.4	38	38	70	132	38	49	68	51	69	94
4.6	35	35	66	125	35	46	64	48	65	90
4.8	31	32	61	117	32	43	60	45	61	85
5.0	28	30	56	110	30	39	56	43	58	79
5.2	26	27	53	103	27	36	53	40	54	74
5.4	<25	25	50	98	25	34	50	36	50	68
5.6		<25	46	93	<25	31	47	34	47	65
5.8			44	87		29	44	31	44	62
6.0			41	84		27	42	29	41	59
6.2			39	80		26	40	27	38	56
6.4			36	75		25	38	25	36	53
6.6			34	71		<25	36	<25	34	50
6.8			32	66			34		32	47
7.0			30	63			31		30	45
7.2			29	60			30		29	43
7.4			27	58			29		27	41
7.6			26	56			27		25	39
7.8			25	54			26		<25	37
8.0			<25	51			25			35
8.2				49			<25			34
8.4				47						32
8.6				45						30
8.8				42						29
9.0				40						28
9.2				38						26
9.4				36						25
9.6				35						<25
9.8				33						
10.0				32						
10.2				31						
10.4				29						
10.6				28						
10.8				27						
11.0				26						
11.2				25						
11.4				<25						

Tablica 2. Vrijednosti izmjerenih sila u centi Newton jedinicama primjenom različitih dimenzija magneta s inklinacijom uzdužnih osi obaju magneta od 10 stupnjeva.

Table 2 Values of measured forces in centi newton units with the application of different magnet dimensions with inclination of 10 degrees of the longitudinal axis of both magnets

Udaljenost mjerenih magneta (mm) The distance between measured magnets (mm)	DIMENZIJE MJERENIH MAGNETA / THE DIMENSIONS OF MEASURED MAGNETS (promjer*visina u mm) / (dynamometer*height in mm)									
	4*4 4*4	5*2 5*2	5*4 5*4	5.85*6 5.85*6	4*4 5*2	4*4 5*4	4*4 5.85*6	5*2 5*4	5*2 5.85*6	5*4 5.85*6
0.2	248	245	>250	>250	229	>250	>250	>250	>250	>250
0.4	223	224	>250	>250	205	240	>250	>250	>250	>250
0.6	201	202	>250	>250	184	225	248	226	>250	>250
0.8	184	184	>250	>250	169	200	231	204	>250	>250
1.0	163	166	240	>250	158	181	209	185	241	>250
1.2	143	144	217	>250	140	163	197	165	219	>250
1.4	125	126	201	>250	125	148	184	150	198	>250
1.6	111	113	180	>250	111	136	171	135	181	227
1.8	100	101	165	>250	99	125	155	124	164	210
2.0	89	90	148	>250	89	113	145	113	153	197
2.2	81	81	135	249	83	103	132	103	140	180
2.4	74	74	124	227	76	93	122	95	129	166
2.6	66	67	116	201	70	86	111	87	118	155
2.8	61	62	107	188	64	79	104	80	107	142
3.0	56	57	99	175	59	72	97	74	100	134
3.2	52	52	91	162	55	68	89	68	95	123
3.4	48	48	84	155	51	63	82	63	89	114
3.6	44	45	78	144	47	58	78	59	81	107
3.8	40	41	72	134	43	53	72	54	77	101
4.0	37	38	68	126	40	50	68	49	70	95
4.2	35	35	64	117	37	46	63	46	66	88
4.4	32	32	60	110	35	44	59	42	60	83
4.6	30	29	56	104	33	41	54	39	57	77
4.8	27	27	50	98	30	38	51	36	54	73
5.0	<25	25	46	92	28	36	48	34	51	69
5.2		<25	43	86	26	34	45	32	49	65
5.4			41	81	<25	31	43	30	46	61
5.6			38	77		29	41	28	43	58
5.8			36	73		27	38	26	41	55
6.0			34	70		26	36	25	39	52
6.2			32	66		25	34	<25	36	49
6.4			30	62		<25	32		34	46
6.6			28	58			30		32	44
6.8			26	55			29		30	42
7.0			25	53			28		29	40
7.2			<25	50			27		27	38
7.4				48			26		26	36
7.6				46			25		<25	34
7.8				44			<25			32
8.0				42						31
8.2				40						29
8.4				38						28
8.6				36						27
8.8				34						26
9.0				32						25
9.2				30						<25
9.4				29						
9.6				28						
9.8				27						
10.0				26						
10.2				25						
10.4				<25						

Tablica 3. Vrijednosti izmjerenih sila u centi Newton jedinicama primjenom različitih dimenzija magneta s inklinacijom uzdužnih osi obaju magneta od 20 stupnjeva.

Table 3 Values of measured forces in centi newton units with the application of different magnet dimensions with inclination of 20 degrees of the longitudinal axis of both magnets

Udaljenost mjerenih magneta (mm) The distance between measured magnets (mm)	DIMENZIJE MJERENIH MAGNETA / THE DIMENSIONS OF MEASURED MAGNETS (promjer*visina u mm) / (dynamometer*height in mm)									
	4*4 4*4	5*2 5*2	5*4 5*4	5.85*6 5.85*6	4*4 5*2	4*4 5*4	4*4 5.85*6	5*2 5*4	5*2 5.85*6	5*4 5.85*6
0.2	209	208	>250	>250	199	220	245	214	>250	>250
0.4	181	189	>250	>250	174	197	222	189	>250	>250
0.6	162	170	229	>250	151	178	208	176	245	>250
0.8	140	143	205	>250	138	157	189	155	221	246
1.0	131	130	183	>250	127	142	174	141	210	234
1.2	117	119	168	>250	114	128	166	124	191	215
1.4	97	101	149	245	106	114	151	113	166	198
1.6	87	90	137	230	93	103	140	104	145	181
1.8	79	80	127	222	82	94	127	94	133	166
2.0	71	71	117	215	73	86	117	80	121	153
2.2	64	63	107	207	68	79	108	73	111	142
2.4	58	57	98	193	63	74	99	67	103	131
2.6	51	53	91	167	57	66	91	61	93	121
2.8	47	48	85	151	52	61	85	57	85	111
3.0	43	43	78	140	48	55	79	52	79	104
3.2	38	39	72	128	45	51	71	48	73	97
3.4	36	36	67	122	41	47	66	44	67	90
3.6	34	34	62	113	38	44	60	41	61	85
3.8	30	31	58	104	35	41	55	38	58	79
4.0	29	29	54	97	34	38	51	36	55	74
4.2	26	27	50	91	30	35	48	33	51	69
4.4	<25	25	46	90	28	32	44	31	47	64
4.6		<25	44	84	27	30	42	29	45	60
4.8			41	78	25	28	40	27	42	57
5.0			38	73	<25	26	39	25	39	54
5.2			35	68		25	38	<25	37	51
5.4			32	65		<25	37		35	48
5.6			30	62			35		32	45
5.8			29	59			34		31	42
6.0			27	57			33		30	40
6.2			26	54			31		29	38
6.4			25	50			29		28	36
6.6			<25	48			28		27	34
6.8				45			27		25	32
7.0				43			25		<25	30
7.2				41			<25			29
7.4				39						28
7.6				38						27
7.8				35						25
8.0				34						<25
8.2				32						
8.4				31						
8.6				30						
8.8				28						
9.0				27						
9.2				26						
9.4				25						
9.6				<25						

Rasprava

Za ekstruzijske pomake zuba poželjne su lagane kontinuirane sile od 25 do 30 cN-a. Izmjerene vrijednosti privlačnih sila između svih primijenjenih magnetskih parova u ovom eksperimentu pokazale su se dostatnim. Osnovni čimbenici koji utječu na intenzitet privlačne sile jesu međusobni položaj magneti, udaljenost između obaju magneti, te volumen i oblik magneti.

Istraživanje je pokazalo da je najbolji položaj magneti onaj kada su njihove plohe usporedne (Slika 4a, Tablica 1), a svaki drugi položaj smanjuje intenzitet sile. Kod promijenjene inklinacije osi obaju magneti za 10 stupnjeva privlačna se sila smanjuje 10% do 20% (Tablica 2), a kada je inklinacija 20 stupnjeva sila opada za 30% do 40% (Tablica 3). Ovisnost intenziteta sile o udaljenosti magneti nedvojbeno je dokazana i u našem pristupu. Dobiveni rezultati slažu se s nalazima ostalih autora (2, 12, 13) i upozoravaju na činjenicu da povećanjem udaljenosti magneti intenzitet sile znatno brže opada kod manjih razmaku, a kod većih međusobnih razmaka magneti sporije opada.

Iz rezultata, dalje proizlazi da oblik i volumen magneti znatno utječu na intenzitet privlačne sile. Jaču privlačnu silu stvaraju magneti veće površine polova, a manje visine. Tako, primjerice, magneti promjera 5 mm i visine 2 mm (volumen a 39,25 mm³) privlače feromagnetični predmet približno istom silom kao magneti promjera 4 mm i visine 4 mm a znatno većeg volumena (50,24 mm³).

Indikacija za kirurško ortodontski tretman impaktiranoga zuba ovisi o više čimbenika od kojih su najvažniji njegov položaj i raspoloživi prostor za pravilan smještaj u zubni luk. Položaj zuba određuje međusobni odnos magneti, a njegova udaljenost zahtijeva izbor veličine magneti. Pri prirodnom procesu nicanja zub se kreće koronarnim dijelom u smjeru uzdužne osi; zato tijekom tretmana valja u najvećoj mjeri simulirati prirodni model kretanja zuba kroz čeljust. Ako to nije moguće, magneti treba postaviti u međudnos tako da prouzroče što manje neželjenih pokreta unutar čeljusti. Uzimajući u obzir navedeno, može se ustvrditi da je odnos magneti definiran kao model "a" najprirodniji, a da su ostali modeli manje povoljni (Slika 4). Kada se planira tretman, bitno je utvrditi udaljenost impaktiranoga zuba od njegova rekonstruiranog ishodišnog

položaja te temeljem podataka u tablicama, uz pretpostavku mogućnosti povoljnog smještaja unutrašnjeg magneti, odrediti odgovarajuće dimenzije obaju magneti. Pritom valja paziti da se udaljenost umanjiti za visinu planiranoga magneti i debljinu vezivnog materijala, što znači da se zub prividno približuje za tu vrijednost. Položaj i dimenzija vanjskoga magneti ovisi o raspoloživu prostoru za smještaj retiniranoga zuba u prirodni položaj.

Na temelju provedenog istraživanja možemo zaključiti da magneti kao izvorišta sila ispunjavaju osnovne pretpostavke za uporabu u kirurško-ortodontskom tretmanu retiniranih zuba. Pri procjeni odluke o kliničkoj primjeni valja imati na umu da s gledišta mogućeg štetnog djelovanja magnetskog polja na okolna tkiva (14-23) još uvijek nema konzensusa među mnogima koji se bave tom problematikom.

Zaključci

Na temelju dobivenih rezultata može se zaključiti da su Sm - Co 5 magneti dimenzija uporabljivih u usnoj šupljini dostatni izvori ortodontskih ekstruzijskih sila za tretman impaktiranih zuba. Intenzitet magnetskih privlačnih sila ovisi o međusobnom položaju, udaljenosti, obliku i volumenu magneti. Uporaba magneti omogućuje stalan nadzor smjera kretanja impaktiranoga zuba od samog početka tretmana. Rezultati ove teoretske studije upućuju na mogućnost kliničke uporabe magneti kao izvora sila pri tretmanu impaktiranih zuba.

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Possibilities for Treatment of Impacted Teeth by the Application of Permanent Magnets

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Summary

Traditional surgical-orthodontic treatment of impacted teeth has certain disadvantages, which has led to the recent investigations of this problem.

The present investigation was undertaken with the aim of establishing whether Sm - Co5 magnets, of a dimension applicable in the oral cavity, are a worthy source of extrusional force; suggesting the optimal position of magnetic segments during the treatment procedure of the impacted tooth; objectifying the direction of tooth movement during the procedure, and concluding the eventual clinical applicability of the investigated procedure.

The sample consisted of 4 pairs of cylindrical magnets, of different dimensions (4x4, 5x2, 5x4 and 5.85x6 mm) and volume, whose magnetic field was directed parallelly with the longitudinal axis. Changes in intensity of the magnetic force within the magnetic field were analyzed by dynamometry, within original construction. In the simulated procedure in vitro the direction of movement of an impacted tooth was observed on an acrylic model of the upper jaw with the application of a natural tooth with an attached inner magnet and a conventional orthodontic plate to support the outer magnet.

Results indicate that the measured values of forces of magnets of suitable dimensions, are adequate - for extrusion of the impacted tooth. The intensity of the force depends on the distance of the magnets and their dimensions. When the gap between the magnets is increased the intensity of the magnetic force drops significantly at the start of shorter distances. Four basic positions for the magnet were established and the direction of movement of the impacted tooth, within the magnetic field, is predictable in each phase of the procedure. The results acquired in this study indicate the clinical applicability.

Key words: magnets, permanent magnets, impacted teeth, magnetic force, extrusion of teeth

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Introduction

Magnets have been used in orthodontic treatment for 20 years, although relatively rarely and restricted to certain types of anomalies. Kawata and Takeda (1) were among the first to report the possibility of applying permanent magnets as an alternative to traditional sources of active force in orthodontics, using them as a substitution for brackets. Blechman (2), Giannelly et al. (3,4), Cozzani et al. (5), Cosentino & Amato (6) and Bondemark & Kurol (7) use magnets in the treatment of class II. Treatment of open bite by intrusion of lateral teeth was described by Dellinger (8), Woods & Nanda (9) and Kiliaridis et al. (10). Mišolić (11) contemplated the theoretical possibility of treating impacted teeth by the application of permanent magnets as a source of orthodontic force.

The problem of treating impacted teeth has always been present in orthodontics, and the procedures used show certain deficiencies and indicate the need for further research.

The aim of the present investigation was to: establish whether Sm - Co 5 (samarium-cobalt) magnets, of suitable dimension for application in the oral cavity, are a sufficient source of extrusional force; determine the optimal positions of magnetic segments for attaining movement of the impacted tooth; objectify the directions of the desired movement of the impacted tooth, and, on the basis of an experiment, to conclude the clinical applicability of the procedure.

Material and methods

During the experiment 4 pairs of Sm - Co 5 cylindrical magnets were applied (BH) max 28 MGOe (225 KJ/m³), dimensions 4x4, 5x2, 5x4 and 5.85x6 mm. The magnets were polished smoothly with the magnetic field directed parallelly with the height axis. The intensity of the magnetic forces between the magnets was measured by the application of the source construction, which is described in Figure 1. The values between the pairs of magnets and their different combinations were measured by dynamometry, which is a component part of the equipment. The construction of the device enables measurement of the magnetic forces at distances of 0.2

to 30 mm, in segments of 0.20 mm, in three different positions: height of the axis of both magnets identical; height of the axis inclined at an angle of 10 degrees and height of the axis inclined at an angle of 20 degrees.

For the experiment, in which the direction of movement of the impacted tooth was simulated, an acrylic model was made of the right half of the upper jaw in natural size. On the top of the crown of the natural right canine a Sm - Co 5 magnet was attached by bonding, 5x4 mm in size (diameter x height). The canine tooth was placed inside the anticipated area of the model jaw in different positions, filled with dense transparent vaseline, which imitated the resistance of the natural tissue during tooth movement. The relevant half of a standard orthodontic plate was used as a support for an outer magnet of the same dimensions (Figures 2 and 3). The difference in the directions of movement of the impacted tooth was analyzed in this magnetic field between the magnets.

Results

Changes in the intensity of the force within the magnetic field between the different dimensions of the magnets, and three of their different axial directions were recorded with centi newton units in tables (Tables 1,2,3). Although the main object of interest was the impacted tooth, the investigation also indicated that the mutual relation of the magnets has a basic role in its movement. Results of an analysis of the directions of the movement of the impacted tooth indicated four basic mutual positions of the magnet (Figure 4). Regardless of the initial position of the impacted tooth in the jaw its starting position can be in one of these four positions, and its direction of movement, depending on the relation of the magnets, will be in accordance with one of the four movement models (Figure 5).

Discussion

For extrusional movement of teeth continuous light force of 25 to 30 cN is desirable. The measured values of the magnetic force between all the magnetic pairs used in this experiment proved to be

adequate. The basic factors influencing the intensity of the magnetic force are, the mutual position of the magnets, distance between magnets and their volume and form.

It was found that the optimal position of the magnets is that in which their surfaces are parallel (Figure 4a, Table 1) while all other positions reduce the force intensity. When the inclination of the axis of both magnets is changed by 10 degrees the magnetic force is reduced by 10% to 20% (Table 2), and when the inclination is changed by 20 degrees the force is reduced by 30% to 40% (Table 3). Dependence of the force intensity on the distance of the magnets was also clearly demonstrated in our approach. The results obtained corroborate the findings of other authors (2, 12, 13) and indicate that by increasing the distance of the magnets the force intensity falls significantly faster in smaller distances compared to the slower fall of the force in the case of larger gaps between the magnets.

Furthermore, the results indicate that the shape and volume of the magnet has a significant influence on the intensity of the magnetic force. Greater magnetic force is created by magnets with larger surface poles and less height than the reverse. For example, magnets of 5 mm diameter and 2 mm height (volume 39.25 cub. mm) attract ferromagnetic objects with approximately the same force as magnets of 4 mm diameter and 4 mm height and significantly greater volume (50.24 cub. mm).

Indication for surgical orthodontic treatment of the impacted tooth depends on several factors, of which the most important is its position and available space for correct location in the dental arch. The position of the impacted tooth determines the mutual relation of the magnets, and its distance determines the choice of magnet size.

During the natural process of eruption the tooth pushes by the coronary part in the direction of the longitudinal axis. Thus, during treatment, the natural model movement of the tooth through the jaw should be simulated to the greatest possible degree.

Should this be impossible, the magnets should be placed in mutual relation, so as to cause as little undesired movement within the jaw as possible. If the foregoing is accepted it can be said that the relation of the magnets defined as model "a", is the most natural, while the remaining models are less suitable (Figure 4). When planning treatment the distance of the impacted tooth from its reconstructed starting position must be determined, and based upon data in the tables, and on the assumption of the possibility of suitable positioning of the inner magnet, the relevant dimension of both magnets should be determined. The distance should be reduced by the height of the planned magnet and density of the binding material, so that the tooth approximates this value. The position and dimensions of the outer magnet depend on the available space for positioning the impacted tooth in a natural position.

On the basis of this investigation it can be concluded that magnets, as a source of force, fulfil the basic requirements for application in surgical-orthodontic treatment of impacted teeth. However, prior to deciding on clinical application it should be kept in mind that there is still no consensus among many scientists engaged in this problem, with regard to the possible harmful effect of the magnetic field on surrounding tissue (14-23).

Conclusions

Based on the results obtained it can be concluded that Sm - Co 5 magnets, of dimensions applicable in the oral cavity, are a worthy source of orthodontic extrusional force for treatment of impacted teeth. The intensity of the magnetic force depends on the mutual position, distance, shape and volume of the magnet. Application of magnets enables permanent control of the direction of movement of the impacted tooth at the start of treatment. The results of this study indicate the possibility of clinical application of magnets as a source of force in the treatment of impacted teeth.