An EMG Analysis of Temporal Muscle Function in Complete Denture Wearers at Two Observation Stages

Elektromiografska analiza funkcije musculus temporalisa kod nosilaca totalnih proteza u dva vremenska razdoblja

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Summary

Activity of anterior and posterior temporal muscles was electromyographically examined in thirty complete denture wearers at the denture insertion and after a 2 – 5 week period of denture wear. Muscle activity was recorded by surface electrodes on a 4 channel poligraphic apparatus during maximum voluntary biting in maximal intercuspal and retruded occlusal positions, as well as in incisal and left and right occlusal positions. Activity of both, anterior and posterior temporal muscles increased after the 2 – 5 week period of denture wear, compared to the insertion stage. The biggest increase of anterior and posterior temporal muscle activity was in maximal intercuspal and retruded occlusal positions ($p < 0.01$ for RAT, LAT, LPT, $p < 0.05$ for RPT in maximal intercuspal position; $p < 0.01$ for RAT, LAT, RPT, $p < 0.05$ for LPT in retruded occlusal position). This could be attributed to the dominance of voluntary central command over the pool of motoneurons of the V motor nucleus with bilateral distribution of voluntary muscle efforts in these positions. The increase of anterior and posterior temporal muscle activity was not of great significance, or none at all in incisal and left and right occlusal positions ($p < 0.05$ for RAT and LPT, $p > 0.05$ for LAT and RPT in incisal position; $p < 0.05$ for RAT, RPT, LPT, $p < 0.01$ for LAT in the left occlusal position; $p > 0.05$ for LAT, RAT, LPT and RPT in the right occlusal position). This could be attributed to the greater involvement of peripheral sensory receptors and consequent prolonged establishment of neuromuscular feedback mechanisms.

Period of neuromuscular adaptation to the dentures is prolonged considering incisal and left and right occlusal positions, compared to the maximal intercuspal and retruded occlusal positions.

Key words: *anterior and posterior temporal muscle, complete dentures, occlusal positions, follow up study.*

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Introduction

Masticatory muscles are capable of performing various movements of the mandible. The precise pattern of each muscle activity depends on reflex co-ordination through the afferent and efferent connections of the participating muscle and the other parts of the masticatory apparatus with the central nervous system. Changes in any part of the stomatognathic system, such as the loss of teeth and the insertion of complete dentures influence the activity of masticatory muscles. The functional state of stomatognathic system in patients with complete dentures has been electromyographically studied (1 – 6) and the results showed that muscle activity during maximum biting was markedly lower in patients with complete dentures than in those with natural dentition. Muscle activity was also studied (6 – 11) in patients with complete immediate dentures and partial lower dentures, but there are no available data of muscle activity in complete denture wearers in different occlusal positions.

Therefore, the aim of this study was to examine the activity of anterior and posterior temporal muscles in different occlusal positions at two stages: (a), at the denture insertion and (b), after a 2 – 5 week period.

Material and Methods

Thirty complete denture wearers were examined in this study. The sample consisted of 6 men and 24 women, ranging from 49–82 years of age, with a mean of 65.7 years of age.

Action potentials from the anterior and posterior part of temporal muscles were recorded twice (a), when the new complete dentures were delivered to the patient and (b), after the period of 2 – 5 weeks, during which neuromuscular adaptation to the dentures should be completed. Between the two stages, all occlusal adjustments were made and sore spots and mucosal inflammation from the excessive denture flanges or undercuts were removed. EMG recordings were made by surface electrodes while subjects were sitting in a comfortable dental chair with their head in upright position and the Camper's line in horizontal position. The surface electrodes for the anterior part of temporal muscle were attached to the skin over the anterior portion of temporal muscle, according to the technique described by Nikšić (12) by using flexible triangles. Positions for the electrodes were marked on the skin through the perforations of the triangle (Figure 1).

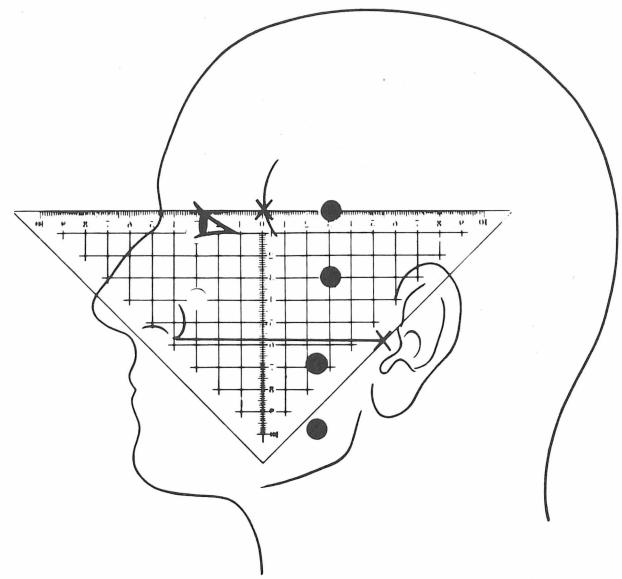

Figure 2. *Positions for the electrodes on the skin over posterior part of temporal muscle*

Slika 2. *Pozicije elektroda na koži iznad stražnjeg dijela m. temporalisa*

To record the activity of the posterior part of temporal muscle, the method described by Čelebić was used (13). The first electrode was placed 1 cm above the ear insertion, at the vertical line which passes through the center of the external auditory meatus and is parallel to Camper's line. The second electrode was placed 1.5 cm posterior to the first electrode (Figure 2).

The method of surface electromyography and bipolar recordings was used on a 4 channel ink-writing poligraphic device with incorporated digital integrators. The apparatus was calibrated so that an input signal of 100 microvoltes produced an ink-writer deflection of 10 mm and 15 impulses of digital integrator per second on each channel. The value of 1 impuls was 6.67 microvoltes.

The muscle activity was recorded during maximum voluntary biting in positions of maximum intercuspation, retrusion, as well as in incisal and left and right occlusal positions, for a

period of 2 seconds; at least it was repeated three times.

Means of the digitally integrated sums of action potentials from the three recordings for the examined occlusal positions were statistically analysed to estimate the average value. As the multivariant analysis (14) revealed the existance of a difference between the two recordings, the significance of the differences was tested by t test (15).

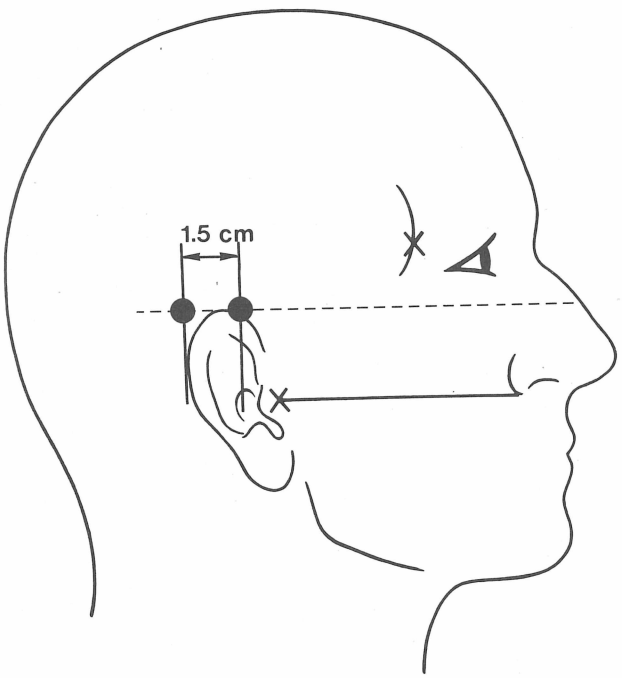

Figure 1. *Positions for the electrodes on the skin over anterior part of temporal muscle are marked through the perforations of the triangle*

Slika 1. *Pozicije elektroda na koži iznad prednjeg dijela m. temporalisa označene su kroz perforacije fleksibilnog trokuta*

Results and Discussion

As there were no data available of temporal muscle activity in complete denture wearers in different occlusal positions during maximum voluntary biting, EMG activity from the anterior and posterior part of temporal muscle was recorded when the new dentures were delivered to the patient and after a 2–5 week period of denture wear. Results from the first recording are shown in table 1 and results from the second recording are shown in table 2.

Comparison of the anterior and posterior temporal muscle activity recorded at the two observation stages, reveals greater activity in all examined occlusal positions at the second observation stage. As the means in both recordings were normally distributed, the significance of the mean differences between the recordings was tested by using t test.

The mean differences (with standard deviations and ranges) of temporal muscle activity between recordings at denture insertion and after a 2–5 week period of denture wear are shown in table 3, for all examined occlusal positions.

The level of significance of mean differences of anterior and posterior temporal muscle activity between the two observation stages is shown in table 4, for all occlusal positions. The difference of anterior and posterior temporal muscle activity was significantly bigger after the 2 – 5 week period in maximal intercuspal position ($p < 0.01$ for RAT, LAT and LPT, $p < 0.05$ for RPT, table 4) and in retruded position ($p < 0.01$ for RAT, LAT and RPT, and $p < 0.05$ for LPT, table 4).

The difference of anterior and posterior temporal muscle activity in incisal and right and left occlusal position is not of great significance ($p < 0.05$ for RAT and LPT in incisal position, $p < 0.05$ for RAT, RPT and LPT and $p < 0.01$ for RPT in left occlusal position, table 4), or none at all ($p > 0.05$ for LAT and RPT in incisal position, and $p > 0.05$ for RAT, LAT, RPT and LPT in right occlusal position, table 4).

From the obtained data, it is obvious that statistically significant increase of anterior and posterior temporal muscle activity after the 2 – 5 week period of denture wear is the greatest in maximal intercuspal position, which is in agreement with previous investigation by Nikšić (16) and in retruded occlusal position. Increase of anterior and posterior temporal muscle activity in other occlusal positions is not so obvious, and shows greater variations (table 1, 2, 3 and 4).

In patients with complete dentures periodontal receptors are missing, but mucosal, Golgi organs, TMJ receptors, as well as nocicceptive receptors (17) are involved in feedback mechanisms on the masticatory elevator muscles, with mucosal receptors playing the main role. It has even been demonstrated that mucosal receptors present higher threshold than periodontal mechanoreceptors (18). Hellsing (19) concluded that in maximum voluntary efforts the motor activity may function without significant involvement of the peripheral mechanisms, which indicates the dominance of voluntary central

Table 1 *Activity of anterior and posterior temporal muscle in different occlusal positions in complete denture wearers at denture insertion*
($\bar{x}$ = arithmetic mean, SD = standard deviation, MIN-MAX = range)*
* *Arithmetic means are numbers of digital impulses through a 2 second period. Value of 1 impuls is 6,67 mV*

Tablica 1. *Aktivnost prednjeg i stražnjeg dijela m. temporalisa u različitim okluzalnim položajima kod nosilaca totalnih proteza prilikom predaje proteza*
($\bar{x}$ = aritmetička sredina, SD = standardna devijacija, MIN-MAX = raspon)*
* *Aritmetičke sredine prikazane su u digitalnim impulsima kroz period od 2 sekunde. Vrijednost jednog impulsa je 6,67 mV*

OCCLUSAL POSITIONS	MUSCLE ACTIVITY											
	RAT			LAT			RPT			LPT		
	$\bar{X}$	SD	MIN-MAX	$\bar{X}$	SD	MIN-MAX	$\bar{X}$	SD	MIN-MAX	$\bar{X}$	SD	MIN-MAX
maximal intercuspal p.	12.46	6.26	2.9 – 31.7	11.46	5.57	3.1 – 22.0	5.97	4.99	0.1 – 22.0	5.20	4.69	0.1 – 20.0
retruded p.	17.68	8.68	3.3 – 40.5	15.75	7.89	3.7 – 29.3	13.31	9.54	0.1 – 41.3	10.82	7.52	0.1 – 27.8
incisal p.	4.07	2.00	0.8 – 9.0	4.09	2.83	0.5 – 10.7	3.14	2.57	0.1 – 12.0	2.59	1.46	0.1 – 7.0
right occlusal p.	15.04	8.13	3.0 – 38.3	4.44	2.94	0.0 – 12.0	10.39	8.65	0.1 – 38.7	3.30	3.59	0.1 – 20.0
left occlusal p.	4.32	2.76	1.2 – 12.0	13.15	6.45	2.3 – 26.7	2.88	1.86	0.1 – 7.33	7.94	6.33	0.1 – 24.0

RAT = right anterior temporal muscle, LAT = left anterior temporal muscle, RPT = right posterior temporal muscle, LPT = left posterior temporal muscle

RAT = desni temporalis anterior, LAT = lijevi temporalis anterior, RPT = desni temporalis posterior, LPT = lijevi temporalis posterior

Table 2 *Activity of anterior and posterior temporal muscle in different occlusal positions in complete denture wearers after a 2 – 5 week of denture wear*
($\bar{x}$ = arithmetic mean, SD = standard deviation, MIN-MAX = range)*
* *Arithmetic means are numbers of digital impulses through a 2 second period. Value of 1 impuls is 6,67 mV*

Tablica 2. *Aktivnost prednjeg i stražnjeg dijela m. temporalisa u različitim okluzalnim položajima nakon perioda od 2 – 5 tjedana nošenja totalnih proteza*
($\bar{x}$ = aritmetička sredina, SD = standardna devijacija, MIN-MAX = raspon)*
* *Aritmetičke sredine prikazane su u digitalnim impulsima u periodu od 2 sekunde. Vrijednost jednog impulsa je 6,67 mV*

OCCLUSAL POSITIONS	MUSCLE ACTIVITY											
	RAT			LAT			RPT			LPT		
	$\bar{X}$	SD	MIN-MAX	$\bar{X}$	SD	MIN-MAX	$\bar{X}$	SD	MIN-MAX	$\bar{X}$	SD	MIN-MAX
maximal intercuspal p.	19.92	11.76	6.0 – 58.7	18.21	7.84	5.8 – 38.0	9.95	8.14	2.0 – 36.7	8.59	7.64	2.2 – 41.7
retruded p.	26.19	13.12	10.0 – 58.0	21.41	9.33	4.6 – 51.7	20.12	12.32	3.5 – 51.3	15.58	11.54	2.3 – 51.0
incisal p.	6.06	5.64	1.3 – 25.0	5.13	4.01	1.0 – 20.7	3.81	2.28	1.0 – 10.3	3.35	2.10	1.0 – 12.0
right occlusal p.	19.04	3.87	6.0 – 52.7	5.74	4.60	0.0 – 17.7	13.01	7.95	2.0 – 29.3	3.65	2.44	1.0 – 12.7
left occlusal p.	5.78	4.01	1.3 – 17.0	18.08	9.92	4.7 – 46.0	3.69	1.69	1.2 – 8.3	10.76	7.59	1.8 – 28.0

RAT = right anterior temporal muscle, LAT = left anterior temporal muscle, RPT = right posterior temporal muscle, LPT = left posterior temporal muscle

RAT = desni temporalis anterior, LAT = lijevi temporalis anterior, RPT = desni temporalis posterior, LPT = lijevi temporalis posterior

Table 3 *Mean differences of temporal muscle activity between recordings at denture insertion and after a 2 – 5 week period in different occlusal positions*
$\bar{x}$ = *arithmetic mean, SD = standard deviation, MIN-MAX = range*

Tablica 3. *Razlike u aktivnosti m. temporalisa prilikom predaje totalnih proteza i nakon perioda od 2 – 5 tjedana nošenja proteza u različitim okluzijskim položajima*
$\bar{x}$ = *aritmetička sredina, SD = standardna devijacija, MIN-MAX = raspon*

OCCLUSAL POSITIONS	MUSCLE ACTIVITY											
	RAT			LAT			RPT			LPT		
	$\bar{X}$	SD	MIN-MAX	$\bar{X}$	SD	MIN-MAX	$\bar{X}$	SD	MIN-MAX	$\bar{X}$	SD	MIN-MAX
maximal intercuspal p.	7.46	10.34	– 9.0 – 40.0	6.75	8.07	– 9.3 – 26.7	3.98	9.29	– 18.8 – 32.0	3.39	6.44	– 4.7 – 31.5
retruded p.	8.51	12.83	– 11.5 – 39.0	5.67	10.52	– 13.7 – 28.3	6.81	13.32	– 30.3 – 45.3	4.76	11.01	– 21.3 – 39.0
incisal p.	1.99	5.19	– 4.5 – 19.3	1.04	3.98	– 4.8 – 16.3	0.66	2.49	– 9.3 – 5.5	0.76	1.96	– 2.3 – 7.3
right occlusal p.	4.01	11.10	– 15.0 – 32.2	1.29	4.72	– 6.9 – 15.0	2.70	10.12	– 19.7 – 22.7	0.35	4.20	– 17.0 – 9.2
left occlusal p.	1.46	3.64	– 5.0 – 11.2	4.93	9.29	– 10.8 – 26.0	0.81	2.09	– 4.5 – 5.5	2.82	6.23	– 13.3 – 20.3

RAT = right anterior temporal muscle, LAT = left anterior temporal muscle, RPT = right posterior temporal muscle, LPT = left posterior temporal muscle

RAT = desni temporalis anterior, LAT = lijevi temporalis anterior, RPT = desni temporalis posterior, LPT = lijevi temporalis posterior

Table 4 *Level of significance of mean differences of anterior and posterior temporal muscle activity at 2 observation stages: at denture insertion and after a 2 – 5 week period*

Tablica 4. *Značajnost razlike aktivnosti prednjeg i stražnjeg dijela m. temporalisa između 2 faze EMG ispitivanja: prilikom predaje totalnih proteva i nakon perioda od 2 – 5 tjedana nošenja proteza*

OCCLUSAL POSITIONS	MUSCLE ACTIVITY								NUMBER OF PAIRS
	RAT		LAT		RPT		LPT		
	t	p	t	p	t	p	t	p	
maximal intercuspal p.	3.95	++	4.58	++	2.35	+	2.88	++	30
retruded p.	3.63	++	2.95	++	2.80	++	2.37	+	30
incisal p.	2.10	+	1.43	–	1.46	–	2.11	+	30
right occlusal p.	1.98	–	1.50	–	1.46	–	0.46	–	30
left occlusal p.	2.21	+	2.91	++	2.12	+	2.48	+	30

– = $p > 0{,}05$ t = 2.05 ($p < 0.05$)
\+ = $p < 0{,}05$ t = 2.76 ($p < 0.01$)
++ = $p < 0{,}01$

RAT = right anterior temporal muscle, LAT = left anterior temporal muscle, RPT = right posterior temporal muscle, LPT = left posterior temporal muscle

RAT = desni temporalis anterior, LAT = lijevi temporalis anterior, RPT = desni temporalis posterior, LPT = lijevi temporalis posterior

command over the pool of motoneurons of the V motor nucleus. The biggest increase of anterior and posterior temporal muscle activity during maximum voluntary biting in maximal intercuspal and retruded occlusal positions are in agreement with Hellsing's results, as in these positions voluntary efforts of the temporal muscle activity are distributed bilaterally, with the central command over the motoneurons of the V motor nucleus. In other occlusal positions (incisal, left and right occlusal positions) more sensory receptors are involved with a bigger influence of peripheral mechanisms and consequent prolonged period of neuromuscular adaptation to the dentures.

It is interesting to compare our results with the results of other authors who examined mandibular elevator muscle activity in follow up studies. Tallgren and co-authors (7 – 9) studied EMG activity of temporal and masseter muscle in patients with complete immediate upper and partial lower dentures through a period of 2 years. After the decline of muscle activity upon insertion, clench activity was restored to preextraction level during the first 6 month of denture wear. At 1 year stage the jaw muscle activity even tended to exceed that level and there was no significant changes during second year. The authors related the quick recovery of biting strength to small changes in jaw and occlusal relations, due to preservation of residual dentition in lower jaw.

The same authors (10, 11) also studied masseter and temporal muscle activity in complete immediate upper and lower dentures. Jaw muscle activity during maximum clench, 3 weeks after insertion revealed a decrease in mean voltage, compared to the preextraction period. During the first 6 months of denture wear, the anterior temporal muscle showed further decrease in mean voltage and masseter muscle showed tendency to increase activity. At 1 year observation stage, the anterior temporal muscle finally displayed an increase in mean voltage from the 6 month stage, whereas the masseter muscle activity showed no significant mean changes.

This finding is opposite to our results. While anterior temporal muscle showed a decrease in mean voltage through the first 6 month of denture wear in Tallgren's examinations on immediate complete denture patients, anterior temporal muscle, as well as posterior, showed significant increase of activity after the 2 – 5 week period, in our study. This difference could be attributed to the teeth extraction and insertion of immediate complete dentures at the same moment. Pain from the postextraction wounds could deccelerate recovery of masticatory muscle activity, especially of temporal muscle which is thought to be more sensitive to feedback mechanisms (20). In our study, all the patients had healthy denture bearing area, with the last tooth being extracted at least 3 month earlier. Without nociceptive reflex influences, the activity of the temporal muscle increased significantly in comparison with the insertion stage over a few week period.

Conclusions

1. Activity of the anterior and posterior temporal muscle increased after a 2 – 5 week period of denture wear, compared to the insertion stage, in different occlusal positions during maximum voluntary biting.

2. The biggest increase of anterior and posterior temporal muscle activity was in maximal intercuspal position and in retruded occlusal position ($p < 0.01$ for RAT, LAT, LPT and $p < 0.05$ for RPT in maximal intercuspal position; $p < 0.01$ for RAT, LAT, RPT and $p < 0.05$ for LPT in retruded occlusal position). This could be attributed to the dominance of voluntary central command over the pool of motoneurons of the V motor nucleus in maximal intercuspal and retruded occlusal positions, with the distribution of voluntary efforts of temporal muscle activity bilaterally, without significant influence of peripheral mechanisms.

3. The increase of temporal muscle activity after the 2 – 5 week period was not of great significance ($p < 0.05$ for RAT and LPT in incisal position; $p < 0.05$ for RAT, RPT and LPT, $p < 0.01$ for LAT in the left occlusal position), or showed no significant difference at all ($p > 0.05$ for LAT and RPT in incisal position, $p > 0.05$ for LAT, RAT, LPT, RPT in the right occlusal position) in incisal and right and left occlusal positions. This could be attributed to the greater involvement of peripheral sensory receptors in excentric occlusal positions and consequent prolonged establishment of neuromuscular feedback mechanisms.

It seems that the period of neuromuscular adaptation to the dentures is prolonged, considering incisal, left and right occlusal positions, in comparison to the maximal intercuspal and retruded occlusal positions.

ELEKTROMIOGRAFSKA ANALIZA FUNKCIJE M. TEMPORALISA U NOSILACA TOTALNIH PROTEZA U DVA VREMENSKA RAZDOBLJA

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Sažetak

Elektromiografski je ispitana aktivnost prednjeg i stražnjeg dijela m. temporalisa kod 30 nosilaca totalnih proteza prilikom predaje proteza i nakon perioda od 2 – 5 tjedana. Mišićna aktivnost je snimljena pomoću površinskih elektroda na 4-kanalnom poligrafu za vrijeme maksimalno motivirane voljne mišićne kontrakcije u položajima maksimalne interkuspidacije, retruzije, u incizalnom položaju, kao i u dekstro i sinistro okluziji. Nakon perioda od 2 – – 5 tjedana nošenja proteza, povećala se aktivnost i prednjeg i stražnjeg dijela m. temporalisa. Mišićna aktivnost se najviše povećala u položaju maksimalne interkuspidacije i retruzije ($p < 0,01$ za DTA, LTA, LTP, $p < 0,05$ za DTP u maksimalnoj interkuspidaciji, $p < 0,01$ za DTA, LTA, DTP, $p < 0,05$ za LTP u retruziji). To se može pripisati dominaciji centralnog voljnog upravljanja nad motoneuronima motorne jezgre V. moždanog živca, jer se u ovim položajima mišićna aktivnost pod utjecajem volje distribuira bilateralno. Povećanje aktivnosti prednjeg i stražnjeg dijela m. temporalisa nije bilo toliko signifikantno u incizalnom i lijevom i desnom okluzalnom položaju ($p < 0,05$ za DTA i LTP, $p > 0,05$ za LTA i DTP u incizalnom položaju; $p < 0,05$ za DTA, DTP, LTP, $p < 0,01$ za LTA u sinistrookluziji, $p > 0,05$ za DTA, LTA, DTP i LTP u dekstrookluziji). To bi se moglo pripisati većem utjecaju perifernih senzornih receptora na žvačne mišiće u ovim okluzalnim položajima i posljedično produženog perioda neuromuskularnih »feedback« mehanizama. Period neuromuskularne adaptacije na proteze produžen je u incizalnom položaju u sinistro i dekstrookluziji u odnosu na položaj maksimalne interkuspidacije i retruzije.

Ključne riječi: *prednji i stražnji dio m. temporalisa, totalne proteze, okluzalni položaji, kontrolno ispitivanje.*

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