Outcome of 6-week treatment with transcutaneous electric nerve stimulation compared with splint on symptomatic temporomandibular joint disk displacement without reduction

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The aim of the present study was to compare the effect of transcutaneous electric nerve stimulation (TENS) with the flat occlusal splint in the treatment of temporomandibular joint (TMJ) disk displacement without reduction. Thirty-one patients were included and randomly selected to be treated 6 weeks with either TENS (90 Hz, 30 min, three times/day) or with a flat occlusal splint (24 h/day. Those selected for the TENS group had one electrode placed over the painful TMJ and another electrode over the anterior temporal muscle. The splint group used a conventional flat occlusal splint with cuspid guidance. Both treatment groups visited the clinic once a week. Symptoms and signs were registered before and after treatment. The intensity of pain was recorded with a visual analogue scale (VAS) and with an electronic pocket-sized recorder (Pain-Track) carried 1 week before and also the last week of treatment for continuous registration of pain. Measured with the VAS, half of the patients treated with splints became pain-free or their TMJ pain improved at least 50% both at rest and with jaw function compared with only 6% in the TENS-treated group. With regard to strictly chewing pain, the VAS-registered pain improved in two-thirds of the splint group, compared with 50% of the TENS group. With the Pain-Track device it was found that in most individuals pain was aggravated at mealtimes. The conclusion was that flat occlusal splints in several respects are better than TENS in the treatment of symptoms associated with TMJ disk displacement without reduction. □ *Occlusal splint; temporomandibular joint; temporomandibular joint disk displacement; transcutaneous electric nerve stimulation*

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In most clinical studies the outcome of treatment of temporomandibular disorders (TMD) is generally good. Non-surgical procedures resolve the pain in the large majority of the patients (1–4). Surgical procedures should be reserved for cases in which conservative measures have failed.

The clinical effects of transcutaneous electric nerve stimulation (TENS) on reduction or elimination of pain is recognized to be beneficial in treating both the acute and the chronic pain patient (5) and rheumatic temporomandibular joint (TMJ) disorders (6). The beneficial effects of TENS may include neurologic, psychologic, physiologic, and pharmacologic mechanisms (7). TENS treatment is reported to reduce symptoms in association with TMJ disk displacement, but no controlled studies have been reported.

A reduction of TMJ pain and dysfunction with splint therapy is well documented. The rate of clinical success in treating TMJ dysfunction ranges from 70% to 90% (3). Proposed theories on the effect of splints are occlusal disengagement, restoration of the vertical dimension, maxillomandibular realignment, TMJ condylar repositioning, and cognitive awareness (8). From clinical experience it is known that splints have good effect on the reduction of symptoms in association with disk displacement without reduction (9). However, controlled studies on disk displacement without reduction have scarcely been reported (10).

The aim of this study was to compare two different treatment modalities, the TENS and the flat occlusal splint, in the treatment of symptoms associated with disk displacement without reduction.

Materials and methods

Patients

The study material consisted of patients referred to either the Department of Clinical Oral Physiology, Karolinska Institutet, or the Orofacial Pain Clinic, Postgraduate Dental Education Center, Örebro, because of complaints related to the craniomandibular system. A consecutive series of patients with signs and symptoms of TMJ pain in association with the clinical diagnosis of disk displacement without reduction were asked to participate in the study. The inclusion criteria

were case history information of a sudden onset of limited mouth opening, reported pain from the TMJ area, restricted condylar translation, and natural dentition with occlusal support on at least all premolars.

Case history information was collected—that is, data on previous trauma to the head and neck, general health, medication, sleep disturbances, and stress in private or working life. During the study period, no other kinds of treatment than TENS or splint were done.

Patients with traumatic injuries to the jaw system, systemic inflammatory disorders, pacemakers, or pregnancy were not included in the study.

Thirty-three patients were originally selected for the study. After selection two patients were excluded. One individual could not understand or converse in Swedish, and one discontinued the treatment. Thirty-one patients (5 men and 26 women; median age, 37 years; range, 17–68 years) were then included for efficacy study. These 31 patients gave their informed consent in accordance with the Declaration of Helsinki and were informed about the project. The study was approved by the Human Ethics Committee at Huddinge University Hospital.

Experimental design

The patients were randomly assigned to either of two groups: 6 weeks' treatment with TENS or 6 weeks with an occlusal splint. Evaluation of symptoms and registration of signs were performed before and at the end of the 6-week treatment period. The patients were informed about the status of their jaw system. The clinical registrations before and after treatment, the instructions, and the treatments were performed by the same person.

Splints

A flat occlusal splint with cuspid guidance covering all maxillary or mandibular teeth was used (11). The device was adjusted to even bilateral occlusal contacts in a comfortable centric relation and centric occlusion. The splint was used 24 h/day, including mealtimes, during the 6-week period. The splint was checked and adjusted once a week at the clinic.

TENS

The patients were instructed how to use a portable hand-sized unit (Delta Tens, Spina Medical AB, Bromma, Sweden) working with a frequency of 90 Hz with oval 2-cm^2 electrodes. The active (cathode) electrode was applied over the painful joint, and the inactive (anode) electrode was placed at the anterior border of the temporal muscle 3–4 cm from the affected joint. Electrode gel was applied, and a piece of tape kept the electrodes in place. Patients with bilateral symptoms had the electrodes placed over both TMJs. The stimulation was manually regulated by the patient and kept immediately below the pain threshold for 30 min 3 times/day (12). During the 6-week treatment period the patient visited the clinic once a week for a check-up and a 15-min TENS treatment.

Assessment variables

The symptoms were assessed with three different methods: a questionnaire for collection of data on presenting symptoms, a visual analogue scale (VAS), and an electronic device for pain registration.

The frequency of complaints was registered on a six-step verbal scale: 1 = never, 2 = very seldom, 3 = once a month, 4 = once a week, 5 = several times a week, and 6 = daily. The degree of severity of complaint was registered on a five-step verbal scale: 1 = none or insignificant, 2 = light, 3 = moderate, 4 = severe complaint, and 5 = very severe complaint. Additional symptoms in the TMJ region with regard to function and nonfunction, using yes or no alternatives, were registered (Table 1).

Recording of TMJ pain on opening and at rest was obtained by means of a 100-mm VAS with the ends defined as 'no pain' and 'worst pain imaginable' (13).

The electronic device Pain-Track (Autenta AB, Uppsala, Sweden) is a portable self-recording system for monitoring symptoms over a long time (14, 15). The device was used to register TMJ pain 1 week immediately before start of the treatment and during the last week of the 6-week treatment period. Recordings made during waking hours on 3 consecutive days in the middle of the measuring week were used for statistical analyses.

The Pain-Track system consists of data loggers, an interface, and a software package. The pocket-sized microcomputer-based data logger was carried by the patient all day. The data logger has three controls. One rates the intensity of pain scaled 0 to 6 in accordance with a Duration-Intensity-Behaviour-Scale (DIBS) (16). This scale was discrete numerical categories (seven steps) linked operationally to objectively described behavioral events. The second control was used to indicate registered sleep or waking hours, and the third control was an event indicator used for registration of mealtimes. The electronic sampling interval was 10 min. During waking hours a beep reminded the patient every 30 min to register the present pain level. This beeper was switched off at night. When the recording was completed, the data logger was connected to a personal computer for storage and analyses of data.

The clinical examination included degree of TMJ condylar translation on opening and tenderness judged by digital palpation. The joint and muscle tenderness was graded positive or negative. Joint sounds were registered by digital palpation or with a stethoscope. The maximal inter-incisal distance and the maximal

Table 1. Symptoms at function and at rest. The number of patients with symptoms before and after 6 weeks' treatment with transcutaneous electric nerve stimulation (TENS) or splint

	TENS				Splint				Significance between groups
	p	Before	After	(−/+)	*p*	Before	After	(−/+)	
Symptoms at rest									
Pain from TMJ/head or jaws	NS	13/16	10/16	(5/2)	NS	14/15	8/15	(7/1)	NS
Headache	NS	9/16	6/16	(3/0)	NS	8/15	3/15	(6/1)	NS
Blocked ear	NS	4/16	3/16	(2/1)	NS	6/15	2/15	(4/0)	NS
Tinnitus	NS	4/16	2/16	(2/0)	NS	3/15	1/15	(3/1)	NS
Fatigue of jaw	NS	9/16	5/16	(4/0)	NS	10/15	6/15	(6/2)	NS
Neckache	NS	6/16	6/16	(1/1)	NS	7/15	4/15	(3/0)	NS
Vertigo	NS	6/16	1/16	(5/0)	NS	3/15	1/15	(3/1)	NS
Numbness	NS	2/16	1/16	(1/0)	NS	1/15	1/15	(0/0)	NS
Functional symptoms									
Limited mouth opening	NS	16/16	12/16	(4/0)	NS	11/15	9/15	(3/1)	NS
Painful mouth opening	NS	15/16	14/16	(1/0)	NS	13/15	11/15	(3/1)	NS
Impaired chewing	0.01	13/16	5/16	(8/0)	NS	9/15	6/15	(4/1)	NS
Painful chewing	NS	15/16	11/16	(5/1)	NS	13/15	8/15	(5/0)	NS

The number of patients with reduced (−) or increased (+) symptoms is given in parentheses. TMJ = temporomandibular joint.

laterotrusion (LTR) and protrusion (PTR) were registered at the central incisors. The metric results in range of mandibular movement (ROM) were dichotomized. Forty millimetres was considered to be the lower limit of normal mouth opening (17). LTR right plus left of 14 mm or more and PTR of 7 mm or more were regarded as normal (18).

Radiography

All patients were radiographically examined with an orthopantomogram and with individualized lateral oblique transcranial projection at closed mouth position and at maximal opening. The radiographs were used to exclude bone lesions and to confirm impaired condylar translation.

Table 2. Number of patients with signs before and after 6 weeks of treatment with transcutaneous electric nerve stimulation (TENS) or occlusal splint

	TENS				Splint				Significance between groups
	p	Before	After	(−/+)	*p*	Before	After	(−/+)	
TMJ registrations*									
Impaired condylar translation	NS	17/17	16/17	(1/0)	NS	15/15	11/15	(4/0)	NS
Crepitation	NS	3/17	4/17	(2/3)	NS	4/15	2/15	(3/1)	NS
Palpation tenderness*									
TMJ laterally	NS	12/17	7/17	(6/1)	NS	9/15	8/15	(4/3)	NS
TMJ meatus	NS	8/17	3/17	(6/1)	NS	6/15	4/15	(3/1)	NS
M. temporalis	NS	7/17	2/17	(5/0)	NS	4/15	4/15	(1/1)	NS
M. sternocleido	0.01	10/17	1/17	(9/0)	NS	5/15	5/15	(2/2)	0.004
M. masseter	NS	6/17	6/17	(2/2)	NS	5/15	5/15	(2/2)	NS
Temporalis tendon	NS	12/17	10/17	(3/1)	NS	10/15	5/15	(7/2)	NS
Pterygoid complex	NS	15/17	10/17	(5/0)	0.05	13/15	7/15	(6/0)	NS
Mandibular range of movement†									
Opening < 40 mm	NS	16/16	11/16	(5/0)	0.05	15/15	9/15	(6/0)	NS
PTR < 7 mm	NS	9/16	5/16	(4/0)	NS	8/15	7/15	(2/1)	NS
LTR left + right < 14 mm	NS	4/16	3/16	(3/2)	NS	6/15	3/15	(3/0)	NS

The number of patients with reduced (−) or increased (+) signs is shown in parentheses.
* Only symptomatic side.
† PTR = protrusion; LTR = laterotrusion.

Table 3. Response to 6 weeks of treatment with transcutaneous electric nerve stimulation (TENS) or splint, expressed as the frequency of complaints on a six-step verbal scale

	TENS ($n = 16$)	Splint ($n = 15$)
Better	1 (6%)	6 (40%)
Unchanged	15 (94%)	9 (60%)

$p < 0.04$. Better: reduction of at least 50% of the frequency of complaints; unchanged: reduction of less than 50% of the frequency of complaints.

Statistics

The chi-squared test or Fisher's exact test was used in 2 × 2 contingency tables to compare symptoms and signs between the groups. The McNemar test was used for the significance of changes before and after treatment within each treatment group. Student's t test was used to compare the maximal range of mandibular movement between the groups. When variances at t tests of group mean values were not equal according to the F test of variances, the degrees of freedom were adjusted in accordance with Satterthwaite (19).

The functional symptoms and symptoms at rest listed in Table 1 and the signs in Table 2 were used to form a score. A positive symptom or sign gave one point, giving a maximum of 8 points for the non-functional symptom score, 4 points for the functional symptom score, and 12 points for the sign score. The points were divided by the total number of items and multiplied by 100, giving a score ranging from 0 to 100. Two-tailed tests of significance were used.

Results

TENS was used on 16 patients, and 15 were treated with splints. Two of the five men were randomized to the TENS group and three to the splint group.

All patients except one had unilateral symptoms. The presenting symptoms were mainly functional complaints of pain from the TMJ region on mouth opening and when chewing. Less than one-third of the patients had impaired health, general joint complaints, sleep disturbances, regular use of analgesics, and symptoms affecting professional life. However, with regard to the variables mentioned, no statistically significant differences were found between the TENS and the splint group before treatment.

The duration of symptoms ranged from 2 weeks to 16 years, with a median value of 6 months without significant difference between the groups. One person in each group had symptoms lasting between 14 and 16 years, but more than half of the 31 patients had had their TMJ complaints for less than 12 months.

Questionnaire and clinical registration

All patients had complaints once a week or more before treatment. Forty per cent of the patients in the splint group and only 6% in the TENS group became free from complaints or had a reduced frequency of complaints (Table 3). Before treatment the degree of severity of complaints was moderate to severe in all patients. In the TENS group 19% and in the splint group 40% became pain-free or reduced the degree of severity by 50% or more, but without significant differences between the groups.

With the exception of improved chewing for the TENS group, the functional symptoms and symptoms at rest showed no statistically significant difference within or between the groups (Table 1). Some symptoms were aggravated in individual cases.

A significant decrease of the tenderness was found for the sternocleidomastoid muscle in the TENS group and for the lateral pterygoid muscle in the splint group (Table 2).

The mandibular range of movement improved in the groups but without significant differences (Table 4).

The scores made from the functional symptoms and symptoms at rest (Table 1), the signs (Table 2), and the combination of signs and symptoms and range of mandibular movement are illustrated in Fig. 1. There was significant reduction of the scores in both groups, but no differences between groups were found.

At the end of the treatment period all patients gave a written statement with pre-set reply alternatives on

Table 4. Increase in range of mandibular mobility after 6 weeks of treatment with transcutaneous electric nerve stimulation (TENS) or splint

		TENS				Splint				Significance between groups
	Df	$p <$	n	$\bar{d}$	SD	$p <$	n	$\bar{d}$	SD	
Opening	29	0.003	16	6.06	6.72	0.000	15	5.9	4.18	NS
PTR	29	0.003	16	1.69	1.92	NS	15	0.47	2.33	NS
Total LTR	29	0.026	16	3.25	5.26	0.060	15	2.27	4.22	NS

$\bar{d}$ is the mean value of increase, expressed in millimeters. PTR = protrusion; LTR = laterotrusion.

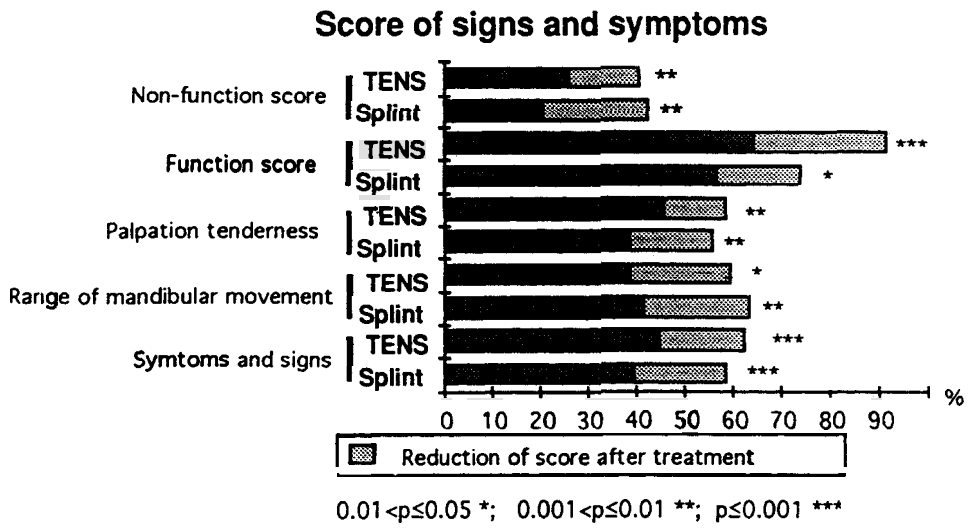

Fig. 1. Reduction of scores after 6 weeks of treatment with transcutaneous electric nerve stimulation (TENS) and splint. The content of the scores is presented in Materials and methods.

how they experienced the outcome of treatment. In the TENS group five patients and in the splint group nine individuals classified themselves as positive responders. The difference between treatment groups was not significant. None of the patients replied that the treatment gave them more complaints.

VAS

The VAS-measured pain at rest before treatment was a mean of 45 mm for the TENS group and 42 mm for the splint group. The functional pain before treatment (pain on chewing and on opening) had a VAS value of 63 mm and 51 mm for the two groups, respectively. At the end of the 6-week treatment more than half of the patients in the splint group indicated a VAS of 0 mm or had reduced their pain by at least 50% both at rest and in function. In the TENS group only 6% had a VAS of 0 mm or had reduced their VAS-measured pain by at least 50% both at rest and at jaw function. The difference was significant (Table 5). The pain at chewing only was eliminated or reduced to half in 56% of the patients in the TENS group, compared with 67% in the splint group.

Table 5. Reduction in pain after 6 weeks of treatment with transcutaneous electric nerve stimulation (TENS) or splint, measured with a visual analogue scale

	TENS ($n = 16$)	Splint ($n = 15$)
Better	1 (6%)	8 (53%)
Unchanged or worse	15 (94%)	7 (47%)

$p < 0.006$. Better: no pain or 50% reduction of pain at rest, chewing, and at opening; unchanged or worse: reduction of pain less than 50% or increased pain.

Pain-Track

The number of minutes of pain was measured with the Pain-Track device. Two individuals in the TENS group were excluded from the Pain-Track evaluation owing to insufficient compliance. Of the total awake time before treatment the patients in the TENS group had pain for a mean of 50% (SD, 36) and the splint group, 67% (SD, 36). After treatment 21% of the patients in the TENS group became pain-free or doubled their pain-free time. The corresponding value for the splint group was 53%. There was no significant difference between the groups.

Pain related to meals lasted mostly no more than 30 min. Therefore the mean intensity of mealtime-related functional pain was evaluated 30 min after the onset of all mealtimes during 3 consecutive days. The mean intensity of mealtime-related pain before treatment on the DIBS scale was 1.5 (SD, 1.2) for the TENS group and 1.3 (SD, 0.8) for the splint group. Half of the patients in the TENS group became pain-free after treatment or reduced their pain by at least 50% at mealtimes. The corresponding value for the splint group was 67%. The figures are comparable with pain in connection with chewing.

Discussion

Other conservative measures than flat occlusal splints and TENS have been presented to treat TMJ pain and

dysfunction. Clothespin joint distraction (20), functional maxillomandibular orthopedic splints (21), modified functional distraction splints (22), non-steroidal anti-inflammatory drugs, corticosteroids, and hyaluronic acid injections (23), counseling, biofeedback, physiotherapy, and jaw manipulation (24) are alternative methods. The present study showed that patients with symptomatic disk displacement without reduction to a certain extent had decreased complaints on a short-term basis with the use of both flat occlusal splints and TENS. In many but not all aspects the occlusal splint was better than TENS in reducing signs and symptoms.

Lundh et al. (25) treated patients with disk displacement without reduction with flat occlusal splints and found that only 32% had become pain-free at the 12-month follow-up. They could not identify significant benefits of a flat occlusal splint over non-treatment control subjects. In our study, 9 patients (60%) of 15 in the splint group and 5 subjects (31%) of the 16 in the TENS group considered themselves to be positive responders after 6 weeks of treatment. Discrepancies in determining the 'success' of a treatment intervention makes it difficult to compare results from various studies. The VAS, behavior scales, numeric scales, verbal scales, and other more or less specified scales are used to evaluate treatment results for TMD complaints. However, the scales are dichotomized, subgrouped, or manipulated in so many variants that comparisons of results are impossible. EMG studies (26) have shown that masseter muscle activity is significantly reduced with a splint. Consequently, reduced load to the TMJ can be one factor for the reduction of symptoms in patients with disk displacement without reduction. Oromandibular parafunction is common among non-patient individuals, and 4% to 20% of the population is aware of bruxism (27). Patients with disk displacement may present bruxism and obtain muscle tenderness. The tenderness can also be due to a faulty disk position through a reflectory muscle spasm (28). TENS seemed to reduce tenderness better than splints in our study. Some subjects also experienced increased tenderness after the therapy, a phenomenon that is well known, especially among splint users. Clark et al. (29) found that 20% of their patients increased their muscle activity by using a splint.

Although the pain-reducing effects of TENS treatment are transitory, repeated applications over a period of several days have been shown to interfere with the pain cycle, so the relief periods may extend from days to weeks (30). The most common side effect during TENS treatment is some type of hypersensibility reaction of the skin. It was mostly seen in slightly underweight patients, in whom contact between skin and electrode was not at its maximum, especially in the area of the TMJ (12).

The success of a palliative home care program depends on patient motivation, co-operation, and compliance. The clinician must take the time for proper counseling, and the time spent for that purpose is a significant factor in developing a high level of treatment compliance (31) and in triggering a placebo effect. Placebo may account for a third to two-thirds of responses in patients with mandibular dysfunction (32). Greene & Laskin (33) studied the effect of meprobamate and placebo on patients with the so-called myofascial pain dysfunction (MPD) syndrome. They found that 58% of the subjects improved with meprobamate and 31% improved with the placebo pill. Greene & Laskin (34) also studied the effect of various splints on MPD patients and found that a non-occluding acrylic palatal plate (placebo splint) improved the symptoms in 40% of the patients, whereas the full-coverage splint improved the symptoms in 80% of the patients. Goodman et al. (35) performed a study on mock equilibration, in which 64% of the patients recovered significantly. Typical for placebo therapy is an improvement in subjective symptoms but little or no improvement in signs of the disorder (36). In our study many signs and symptoms were not changed significantly after either splint or TENS therapy. This may be explained by the relatively small number of patients in each group or that a placebo effect was present, not only in the TENS group but also in the splint group. Møystad et al. (6) used low- and high-frequency TENS on a group of patients with painful rheumatoid diseases of the TMJ. As control they used TENS equipment with the cables interrupted. None of the variables except jaw functional pain, which improved significantly more after high-frequency TENS than placebo TENS, showed any differences between high and low TENS and placebo treatment. Of patients with atypical facial pain and trigeminal neuralgia 32% are reported to have benefited of a group receiving high-frequency TENS evaluated after 3 months (37).

The conclusion of our study was that a flat occlusal splint in several aspects is better than TENS in the treatment of anterior disk displacement without reduction.

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