

**ORIGINAL ARTICLE**

# The course of pain intensity and frequency of adolescents treated because of temporomandibular disorders: A long-term follow-up

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**Abstract**

**Objectives:** To evaluate the course of pain intensity and frequency related to temporomandibular disorders (TMDs) 15 years (range 5–21 years) after having received TMD treatment as adolescents due to frequent (at least once a week) TMD pain in two controlled trials.

**Materials and Methods:** In the first trial, subjects ( $n = 122$ ) were randomly allocated to either information only, received in a control condition (Co), or information and an occlusal appliance (OA) versus relaxation therapy (RT). In the second trial, including 64 subjects, nonresponders to OA or RT were subsequently allocated to the alternate treatment (ST). All study participants having completed the trials ( $n = 167$ ) were invited to a long-term follow-up evaluations, with a response rate of 69.5% ( $n = 116$ ). Patient-reported outcomes of TMD-related frequency and intensity were appraised relative to baseline data and short-term outcomes as observed in the two trials by use of general linear mixed model and generalized estimation equation statistics.

**Results:** A significantly higher proportion of participants treated with OA and in the combined RT/Co condition than those in the ST group, reported a frequency level of TMD pain less than once week at post-treatment and the long-term follow-up. Adolescents treated with OA showed significantly lower TMD pain intensity levels post-treatment than those in the other two treatment conditions. While no difference between the OA and the RT/Co conditions was found in the long-term follow-up, participants in these two conditions were significantly more improved than those in the ST group.

**Conclusion:** Adolescents treated with an OA clearly showed better outcome with regard to intensity and frequency in a long-term follow-up of TMD pain than those treated with RT and ST for nonresponders. These latter individuals need special clinical attention and more effective supplementary treatment methods to be developed.

**KEYWORDS**

adolescence, long-term outcome, occlusal appliance, relaxation therapy, temporomandibular disorders

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## 1 | INTRODUCTION

Temporomandibular disorder (TMD) pain is a common condition in the general population among individuals of all ages (LeResche, 1997). The prevalence rates in surveys of frequent TMD pain in adolescents in general population-based samples have varied between 3 and 7% (Graue, Jokstad, Assmus, & Skeie, 2016; List, Wahlund, Wenneberg, & Dworkin, 1999; Nilsson, List, & Drangsholt, 2005), and the disorder affects approximately 10–15% of the adult population (LeResche, 1997). Frequent TMD may adversely affect the quality of life in all age groups (Dahlström & Carlsson, 2010; Nilsson, List, & Willman, 2011), and is also commonly associated with other recurrent pain conditions, somatic complaints (Hirsch, John, Schaller, & Türp, 2006; List, Wahlund, & Larsson, 2001; Nilsson, List, & Drangsholt, 2013), and anxiety and depression (Hirsch & Türp, 2010; List et al., 2001; Nilsson, Drangsholt, & List, 2009). In a large, population-based study of children and adolescents, Hirsch and collaborators (Hirsch et al., 2006) report that increased experience of bodily pain including TMD pain was associated with greater impairment and increased consumption of painkillers and health care use.

In longitudinal, community-based studies of young individuals, TMD symptoms have been shown to increase with age, and to be more pronounced in females than in males (Egermark, Carlsson, & Magnusson, 2001; Magnusson, Egermark, & Carlsson, 2005; Wänman, 1996). In a prospective survey covering over two decades from childhood into young adulthood, progression to severe TMD pain and dysfunction was rare and so was spontaneous recovery from more pronounced symptoms (Magnusson et al., 2005). While the symptoms often exhibit a fluctuating pattern across time (Egermark et al., 2001; Magnusson et al., 2005; Wänman, 1996), in some individuals, the pain can persist over a long period of time (Nilsson, List, & Drangsholt, 2007).

Whereas approximately 50% of adolescents with frequent TMD pain experience a need for treatment (List et al., 1999; Nilsson, List, & Drangsholt, 2006), only about one-third of them may receive any kind of treatment in dental care clinics (Nilsson et al., 2005). In a qualitative study, young people experiencing TMD pain reported that continued and increasing pain as well as a desire to obtain an explanation for the pain were important reasons for seeking help (Nilsson & Willman, 2016).

From a short-term perspective, a variety of different treatment approaches including the use of occlusal appliance (OA) and various types of cognitive-behavioral interventions, applied separately or in combination, have shown positive outcome effects on TMD pain in adult patients (Al-Ani, Davies, Gray, Sloan, & Glenny, 2004; Liu et al., 2012; Roldán-Barraza, Janko, Villanueva, Araya, & Lauer, 2014; Türp, Komine, & Hugger, 2004). For these age groups, similar long-lasting improvements have been reported in follow-up studies in a majority of patients treated for TMD pain (Behr et al., 2007; Bergström, List, & Magnusson, 2008; Erixon & Ekberg, 2013; Vallon, Nilner, & Söderfeldt, 1998).

By contrast, treatment studies reporting outcomes in adolescents with TMD pain are sparse. We have previously conducted two randomized control trials (RCTs) in which we examined the effects of OA and relaxation therapy (RT), both combined with information (Wahlund, List, & Larsson, 2003; Wahlund, Nilsson, & Larsson, 2015),

compared to information provided in one session (Wahlund et al., 2003). The overall outcome showed a short-term positive outcome for OA in adolescent reports of pain relief (Wahlund et al., 2003; Wahlund et al., 2015). In a previous long-term endpoint follow-up of young adults treated in our two RCTs, those being treated with an OA had sought further treatment significantly less often than those treated with RT. Nonresponders to treatment as well as females showed an overall poorer outcome (Wahlund & Larsson, 2018).

The purpose of the present study was to evaluate the course and changes in intensity and frequency of TMD pain across four time points (baseline, posttreatment, and at the 6-month and long-term follow-up) by treatment condition, as reflected in the outcomes of our two previous RCTs.

## 2 | METHODS

### 2.1 | Participants

The original sample in our two previous RCTs from a consecutive series of patients referred to the Department of Stomatognathic Physiology, Public Dental Health Service, in two Swedish cities, Linköping and Norrköping, included 186 adolescents who were recruited because of frequent TMD pain. Out of this sample, 167 received and completed treatment as described below.

The first RCT included 110 subjects (82 girls and 28 boys, 74.5 and 25.5%, respectively) who received treatment between 1996 and 2000. The patients were randomly assigned to one of following three treatment conditions: (a) OA, and TMD information; (b) RT administered during four therapist-guided sessions, in addition to TMD information; or (c) TMD information given during one session as an untreated control (Co) condition (Wahlund et al., 2003). In RCT2, 57 subjects (54 girls and three boys, 94.7 and 5.3%, respectively) received treatment in two trial phases between 2003 and 2011 (Wahlund et al., 2015). In the first phase, the patients were randomized to either OA or RT (eight sessions), and both groups also received TMD information before randomization. The second phase included a sequential crossover design, in which nonresponders to treatment after phase one (defined as a report of a treatment effect on the Patient Global Impression of Change (Dworkin et al., 2008) as “Slightly improved,” “No change,” “Slightly worsened,” or “Much worse”) were offered the alternate treatment type, OA or RT, thus receiving sequential and combined treatment. In both RCTs and in both phases in RCT2, the patients were evaluated 3 months after treatment initiation and at a short-term, 6-month follow-up.

Inclusion criteria for the two RCTs were: (a) age 12–19 years; (b) a report of pain at least once a week in the face, jaws, temporomandibular joints (TMJs), or temples for at least 3 months; (c) diagnosed according to the Research Diagnostic Criteria for TMD (RDC/TMD) (Dworkin & LeResche, 1992), and (d) wanting treatment. Exclusion criteria were juvenile idiopathic arthritis, migraine, and ongoing orthodontic treatment interfering with OA. A clinical examination was performed in accordance with the RDC/TMD examination

guidelines. The procedure allows establishing the following multiple diagnoses: myofascial pain, disc displacement, and/or arthralgia/arthrosis (Dworkin & LeResche, 1992).

From the two RCT samples and treated adolescents, 167 individuals were then invited to participate in a long-term follow-up evaluation, 116 (69.5%; 80% females) of whom agreed to be enrolled in the present study (for details on the sample, see Table 1). The average follow-up time was 14.8 years (*SD* 4.9), with a range of 5–21 years. A detailed description of individuals and demographic data has been presented elsewhere (Wahlund et al., 2003; Wahlund et al., 2015; Wahlund & Larsson, 2018).

The participants and the parents in the original RCTs were informed about the study and signed a written consent form for participation. Both previous RCTs and the long-term follow-up study were approved by the Regional Medical Ethics Committee in Linköping.

## 2.2 | Treatment

The treatments used in the two previous trials were administered by trained and experienced therapists. The information approach included standardized information on TMD-related anatomy, TMD pain epidemiology, parafunction, and stress. The OA consisted of a stabilization splint placed in the upper jaw, designed to produce maximum occlusion contact with canine guidance. Patients were instructed to use the appliance every night up to the first evaluation and, if needed, to continue its use until the 6-month follow-up.

The RT program was based on clinic-based training and a manual for home training with audio instructions, as used in previous RCTs on adolescents with recurrent headaches (Larsson, Carlsson, Fichtel, & Melin, 2005). The importance of regular home practice at least once a day for 15–20 min was emphasized. In the first trial, four therapist-

guided sessions were administered by a trained dental nurse; in the second trial, eight sessions were conducted. The overall purpose was to provide the adolescents with an active pain coping technique that they could use in everyday situations at the onset of TMD pain.

## 2.3 | Assessment

At baseline, posttreatment, and the short-term (6-month) and long-term follow-ups, the participants registered their TMD pain intensity and frequency in a questionnaire, which also included other pain-related measures, as used in our previous outcome studies (Wahlund et al., 2003; Wahlund et al., 2015; Wahlund & Larsson, 2018).

### 2.3.1 | Pain intensity

Participants rated their experience of intensity of current TMD pain on a 0–10 visual analog scale (VAS), with 0 = “No pain,” and 10 = “Worst pain imaginable” as endpoints.

### 2.3.2 | Pain frequency

The participants were asked to score their pain on a 5-point scale, where 1 = “Never,” 2 = “Once or twice a month,” 3 = “Once a week,” 4 = “Several times a week,” and 5 = “Daily.” Using the inclusion criterion of having TMD pain at least once a week as a cutoff point, the outcome posttreatment and at the short- and long-term follow-ups was dichotomized into “Less than once a week” and “Once a week or more often.”

In RCT1, only minor differences in outcome were obtained between the RT and Co treatment conditions (Wahlund et al., 2003);

**TABLE 1** Distribution of participants ( $N = 186$ ) by treatment group at baseline, posttreatment, and at the 6-month and long-term follow-ups. Figures refer to original, nonimputed data

	All N	OA n	RT/Co n	ST n	Dropout during treatment n
Baseline (all)	186	75	111		
RCT 1	122	42	80	–	12
RCT 2	64	33 <sup>a</sup>	31 <sup>a</sup>	57	7 <sup>a</sup>
Posttreatment (all)	167	58	78		
RCT 1	110	37	73	–	
RCT 2	57	21	5	31 <sup>b</sup>	
6-month follow-up (all)	164	56	78		
RCT 1	110	37	73	–	
RCT 2	54	19	5	30	
Long-term follow-up (all)	114	39	50		
RCT 1	68	22	46	–	
RCT 2	46	17	4	25	

Abbreviations: OA, occlusal appliance; RCT, randomized controlled trial; RT/Co, relaxation therapy/control condition; ST, sequential treatment.

<sup>a</sup>During the first phase of the crossover study.

<sup>b</sup>Participated in the second phase of RCT 2.

consequently, data from these two treatments was pooled together into a combined RT/Co group in the present outcome analyses.

## 2.4 | Statistics

Descriptive statistics included percentages, and means with *SD*. Associations between nominal variables were analyzed with chi-square test. Differences between independent groups on ordinal variables were analyzed using Mann–Whitney test. Analysis of differences between treatment groups and means across the four included repeated measures (for the measurement points baseline, post-treatment, and short- and long-term follow-up) analysis of variance (ANOVA) using pretreatment scores as covariates. Where significant main effects were obtained, subsequent Bonferroni post hoc test was used for pairwise comparisons.

Changes in trajectories across the four time points by treatment condition were further analyzed using general linear mixed model statistics in SPSS version 25.0 (2017) (IBM Corp. Released, 2017). For changes in VAS and in TMD intensity, an unstructured covariance type was used and compared to outcomes with an autoregressive heterogeneous structure, AR(1). The analysis was first carried out using a conditional model (with time and treatment group as fixed factors) in which age and gender were included as covariates. To estimate covariance parameters, restricted maximum likelihood (REML) was used to allow for representation of within-subject correlation of repeated measurement within the same individual. The REML procedure is also able to handle missing data at some time point in the analysis with unbalanced data. The participant (or patient) identity was included as a random effect, so that each individual had a unique intercept, or baseline.

For frequency of TMD pain with a dichotomous outcome variable, a generalized estimation equation (GEE) using a binary logistic model was employed to estimate differences across the three time points, posttreatment, and at short- and long-term follow-up (all adolescents fulfilled the inclusion criteria at baseline), by treatment group.

Potential effects of gender and age as covariates were also examined using an unstructured covariance structure (UN). A *p*-level of .05 indicated statistical significance in our analysis.

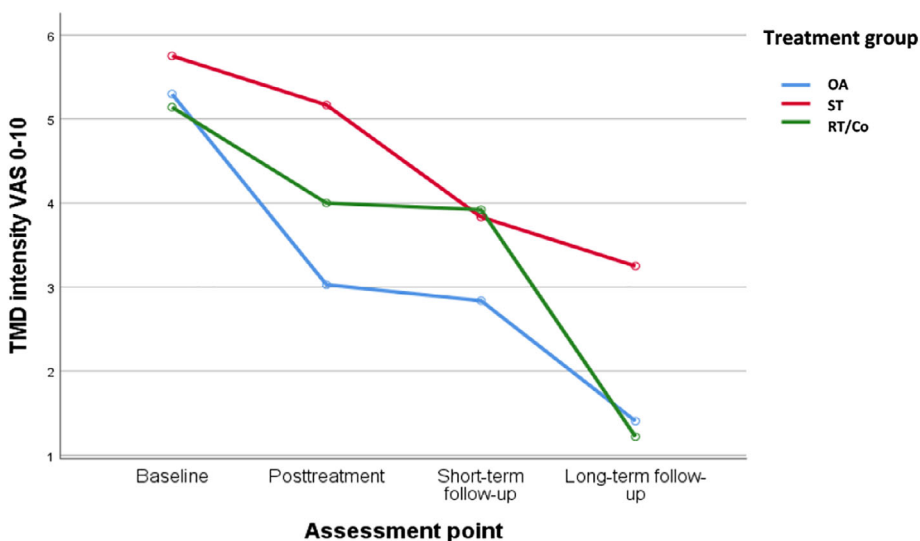
## 3 | RESULTS

The results of a missing value analysis showed no pretreatment differences between treatment completers and dropouts regarding frequency or intensity of TMD pain. Further analysis focusing on levels of treatment credibility, psychological problems, and stress indicated no between-group differences (data and measures not reported here) (Wahlund & Larsson, 2018). Analysis of potential differential dropout was also carried out by estimating effects of gender, age, TMD frequency, and pain intensity posttreatment and at the short-term follow-up with regard to treatment completers or dropouts at the long-term follow-up. While the results showed that mean ranks were significantly lower among dropouts than among participants at the posttreatment measuring point ( $Z = -2.05, p < .05$ ), no difference was found at the short-term follow-up.

### 3.1 | Changes in temporomandibular pain intensity and frequency across time

#### 3.1.1 | VAS intensity scores

The results of repeated measures ANOVA using pretreatment scores as covariates showed significant main effects of time consisting of a strong significant linear effect on the intensity measure at post-treatment, short-term follow-up and long-term follow-up assessments,  $F(1, 110) = 59.22, p < .01$ , and a significant quadratic effect,  $F(1, 110) = 6.80, p = .01$ , with an effect size (ES) of 0.35 and 0.06, respectively (Figure 1). The main effect of treatment group was also strongly significant,  $F(2, 110) = 8.99, p < .01$ , with an ES of 0.14.



**FIGURE 1** Changes in temporomandibular disorder (TMD) pain intensity across the four time points (baseline, posttreatment, short-, and long-term follow-up evaluations) by treatment condition. Figures refer to mean values on the VAS 0–10 scale as reflected by repeated analysis of variance (ANOVA). OA, occlusal appliance; RT/Co, relaxation therapy/control condition; ST, sequential treatment

A significant quadratic time by treatment group interaction effect was also obtained,  $F(2, 110) = 6.61, p < .01$ , with an ES of 0.11.

Subsequent analyses with one-way ANOVA showed homogenous variance and significant between-treatment group effects at all three time points,  $F(2, 169) = 6.97, p < .01$ ;  $F(2, 166) = 4.99, p < .01$ ; and  $F(2, 113) = 8.48, p < .001$ , respectively. The results of Bonferroni post hoc test showed that participants having been treated with OA had significantly lower mean posttreatment intensity scores compared to those treated with RT/Co ( $p < .05$ ) and ST ( $p < .01$ ); however, no significant difference was found between the latter two groups (see Table 2). At the short-term follow-up, although the mean scores again were lower in the OA group than in the other two groups, the difference was significant ( $p < .01$ ) only between the OA and RT/Co groups. Finally, at the long-term follow-up, mean intensity scores were significantly ( $p < .01$ ) lower in the OA and RT/Co groups than in the ST group, with no difference between the first two groups. In a

**TABLE 2** Means and SD (in parentheses) for TMD pain intensity levels (rated on a 0–10 VAS) by treatment group and assessment point (baseline, posttreatment, and at the 6-month and long-term follow-ups) ( $N = 167$ ). Figures refer to the number of adolescents who received treatment

	Treatment group		
	OA	ST	RT/Co
Baseline ( $N = 167$ )	5.5 (1.7) ( $n = 58$ )	5.4 (5.4) ( $n = 31$ )	5.4 (1.9) ( $n = 78$ )
Posttreatment ( $n = 167$ )	3.3 (1.9) ( $n = 58$ )	4.8 (1.9) ( $n = 31$ )	4.2 (2.1) ( $n = 78$ )
6-month follow-up ( $n = 164$ )	2.8 (1.8) ( $n = 56$ )	3.7 (2.3) ( $n = 30$ )	3.9 (2.2) ( $n = 78$ )
Long-term follow-up ( $n = 116$ )	1.5 (2.0) ( $n = 41$ )	3.3 (2.4) ( $n = 25$ )	1.2 (2.1) ( $n = 50$ )

Abbreviations: OA, occlusal appliance; RT/Co, relaxation therapy/control condition; ST, sequential treatment; TMD, temporomandibular disorder; VAS, visual analog scale.

**TABLE 3** Results of GLMM analysis with an unstructured covariance structure, using TMD pain intensity scores (0–10 VAS) as dependent variable, and treatment group and time as fixed factors

	B (SE)	t-Value	p-Value	CI <sub>95%</sub>
Intercept	1.21 (0.30)	4.05	.001	0.62 to 1.80
Treatment group				
OA	0.21 (0.46)	0.46	Ns	–0.69 to 1.11
ST	2.07 (0.51)	4.05	.001	1.06 to 3.09
RT/Co reference	–	–	–	–
Time				
Baseline	4.17 (0.36)	11.45	.001	3.45 to 4.89
Posttreatment	3.00 (0.36)	8.35	.001	2.29 to 3.71
Short-term FU	2.70 (0.36)	7.55	.001	2.00 to 3.42
Long-term FU reference	–	–	–	–

Abbreviations: B, beta coefficient; CI<sub>95%</sub>, 95% confidence interval; FU, follow-up; GLMM, general linear mixed model; OA, occlusal appliance; ns, nonsignificant; SE, standard error; RT/Co, relaxation therapy/control condition; ST, sequential treatment; VAS, visual analog scale.

separate analysis, no interaction effect was found between gender and time.

### 3.1.2 | Results of GLM analysis

Because comparisons in the GLM analysis showed only minor differences in information criteria for model fit between UN covariance and AR(1) heterogeneous structures, outcomes presented below refer to the UN model.

As shown in Table 3 using RT/Co and long-term follow-up as reference points for treatment group and time points, significantly ( $p < .001$ ) lower estimates were found for the RT/Co group than for the ST group, but not for differences between the OA and RT/Co treatment groups. Further analysis (using another reference group) showed that estimates were also significantly lower in the OA group compared to the ST group.

With regard to the four time points, differences in estimates were significantly ( $p < .001$ ) lower for long-term assessment compared to the previous three time points. While results of further analysis showed no differences in estimates between baseline and posttreatment estimates, or between short- and long-term follow-up assessments, all other differences between time points were significant.

### 3.1.3 | Frequency of TMD pain

At posttreatment, there was a significant association between treatment group and frequency of TMD pain (at least once a week, or less),  $\chi^2(2) = 13.95, p < .01$ . Both the OA group and the RT/Co group had a significantly higher proportion of participants (38.1 and 37.2%) with TMD pain less than once a week, with no difference between these two groups, compared to the ST group (3.2%). At the short-term follow-up, although the first two treatment groups still had a higher proportion of participants (50.8 and 44.9%, respectively) with this frequency level, compared to the ST group (26.7%), the association was

	B (SE)	Wald Chi-square	Wald CI <sub>95%</sub>	p-Value
Intercept	-1.27 (0.36)	12.06	-1.98 to -0.55	.001
Treatment group				
OA	0.11 (0.53)	0.05	-0.92 to 1.14	ns
ST	1.78 (0.54)	10.81	0.72 to 2.83	.001
RT/co = reference	—	—	—	—
Time				
Posttreatment	1.93 (0.41)	21.75	1.12 to 2.74	.001
Short-term FU	1.61 (0.41)	15.81	0.82 to 2.41	.001
Long-term FU = reference	—	—	—	—

Note: Baseline values are excluded here because all participants fulfilled the inclusion criterion of having a pain frequency of at least once a week.

Abbreviations: B, beta coefficient; CI, confidence interval; FU, follow-up; GEE, generalized estimation equation; OA, occlusal appliance; RT/Co, relaxation therapy/control condition; SE, standard error; ST, sequential treatment; TMD, temporomandibular disorder.

**TABLE 4** Results of GEE with a binary logistic model using unstructured covariance structure and TMD pain frequency dichotomous scores (pain less than once a week vs. more often) as dependent variable, with treatment group and time as fixed factors. Because no significant interaction effects between treatment condition and time were observed, only main effects are presented here

nonsignificant ( $p = .09$ ). However, at the long-term follow-up, both the OA and the RT/Co treatment groups had a significantly higher proportion of participants (73.2 and 80%, respectively) who had a TMD frequency of pain less than once a week compared to the ST group (40%),  $\chi^2(2) = 12.98, p < .01$ .

### 3.1.4 | GEE analysis

The results of further analysis with GEE using a UN covariance structure and TMD frequency as a dichotomous dependent variable showed that Wald Chi-square test for model effects was significant for the intercept,  $\chi^2(1) = 6.94, p < .01$ , but also for treatment group and change over time (across the posttreatment, and short- and long-term follow-up evaluations),  $\chi^2(2) = 12.63, p < .01$ , and  $\chi^2(2) = 35.69, p < .001$ , respectively. However, the interaction between treatment group and time was nonsignificant. For gender, the effect was modest and nonsignificant ( $p = .07$ ).

Whereas the results of further analysis of parameter estimates showed that they were significantly higher in the ST group (odds ratio [OR] = 5.90; CI<sub>95%</sub> 2.0–16.98) compared to the RT/Co group, the difference between the latter group and the OA group was nonsignificant (see Table 4). A similar difference in estimates was also significant between the OA and ST groups (OR = 4.64; CI<sub>95%</sub> 2.06–10.47).

For changes across the three time points, the overall estimates were significantly higher for posttreatment and the short-term follow-up compared to the long-term follow-up, OR = 6.90; CI<sub>95%</sub> 3.06–15.54, and OR = 5.01; CI<sub>95%</sub> 2.26–11.08, respectively. Subsequent analysis also showed that the difference between posttreatment and short-term follow-up estimates was significant, OR = 1.08; CI<sub>95%</sub> 0.62–1.89.

## 4 | DISCUSSION

This study evaluated the course of intensity and frequency of TMD pain over a long-term period (range 5–21 years after treatment) in

clinically referred adolescents previously treated in two RCTs with an OA, RT, or information given alone, and ST received by nonresponders in a first phase (alternate OA or RT added) of our second RCT in a two-phase crossover design.

The overall results showed that a significantly higher proportion of participants treated with OA and in the RT/Co condition reported a frequency level of TMD pain less than once week (pain at least once a week constituted the inclusion criterion) at posttreatment and the long-term follow-up evaluations compared to participants who did not respond to OA or RT treatments in the first phase in the ST group. While the differences in proportions between the three treatment conditions were strikingly similar in size across the three post-treatment measurement points, they were somewhat attenuated and nonsignificant ( $p = .07$ ) at the short-term follow-up. By contrast, adolescents treated with OA showed significantly lower TMD intensity levels compared to adolescents in the other two treatment conditions. While there was no difference between the OA and the RT/Co conditions in the long-term follow-up, participants in both groups were significantly more improved than those in the ST group consisting of nonresponders to treatment in the first phase of the crossover design in our second trial. Here, reported changes in treated adolescents across time points by treatment condition show differences in group means and proportions as well as in multivariate analysis in which changes were based on differences in slopes, as reflected by beta coefficients. Overall, these different perspectives in our analyses substantiated the main findings of the present study.

OAs and cognitive-behavioral approaches including RT and bio-feedback have in short-term follow-up perspectives been found to produce a reduction in TMD pain in adult patients (Al-Ani et al., 2004; Liu et al., 2012; Roldán-Barraza et al., 2014; Türp et al., 2004). For example, in an evaluation of the effects of appliance therapy, a significant decrease was found in both frequency and intensity of myofascial pain at both 6 and 12 months follow-up (Ekberg & Nilner, 2004). By contrast, no additional effect for splint therapy on pain intensity was found, compared to control treatment including counseling and instructions for masticatory muscle exercise, in another RCT

at a 1-year follow-up in that pain intensity decreased in both treatment groups (Qvintus et al., 2015).

Prolonged and positive outcome effects for OA therapy have also been reported in several long-term follow-up studies of adults (Behr et al., 2007; Bergström et al., 2008; Erixon & Ekberg, 2013; Vallon et al., 1998). In a 7-year follow-up of treatment outcome in 50 adult TMD patients randomly assigned to either a treatment group or an untreated control group, the findings indicated that combined treatment including OA, counseling, occlusal therapy, biofeedback, medication and physiotherapy resulted in a better outcome than single treatment (Vallon et al., 1998). In an 8-year follow-up, adult patients with an RDC/TMD diagnosis of arthralgia/osteoarthritis and/or myofascial pain and treated in a previous RCT evaluated the long-term effect of treatment with an OA compared to a group receiving nonoccluding appliances (Erixon & Ekberg, 2013). The long-term follow-up also included a group of patients who were randomized to the control condition in the original RCT, and had requested treatment with an OA at evaluations 10 weeks and 6 months, respectively, after baseline. While 60% reported an overall 30% reduction in the most severe pain intensity levels, no significant between-treatment group differences were reported. An overall significant reduction in pain frequency over time was also reported in that 12% reported frequent TMD pain at the follow-up, compared to 74% at baseline. More patients who were initially treated with an OA and patients who received combined treatment reported a positive outcome at the long-term follow-up compared to patients receiving control treatment. Although the figures suggest improvement after initial treatment across time, the authors underlined that caution needs to be exercised in the interpretation of their findings in that 60% had received additional treatment during the follow-up period.

In the present long-term follow-up study of adolescent patients with frequent TMD pain, we found the opposite: nonresponders to initial treatment in our second trial showed a significantly lower improvement in TMD intensity and frequency, despite having received additional ST, compared to those in the OA and RT/Co groups. A likely reason for this finding is that nonresponders to treatment in the first phase may be more burdened by other psychological problems, as indicated by findings in our previous long-term study on endpoint effects (Wahlund & Larsson, 2018). In this study, they also reported more pain, depressive symptoms, and a higher degree of impairments than those who responded to single treatment in the first phase. A differential treatment group effect was also observed in about a quarter of the participants in the RT and ST groups, who reported having sought additional treatment during the follow-up period, again reflecting a poorer outcome for these individuals, in contrast to only 9.8% of those treated with OA (Wahlund & Larsson, 2018). Such ameliorating factors thus emerged as possible predictors of treatment outcome in these age groups.

#### 4.1 | Limitations and strengths

While the distribution of gender in the present two trials is likely to reflect the preponderance of girls suffering from TMD pain in the general population, the outcome for the low proportion of males included

and statistical power in the two trials is unclear. It should also be noted that the participants receiving sequential and combined treatment in the second trial constituted a selected group of individuals who were not randomized to crossover treatment in the second phase. Another limitation in the present study is that the responders (62% of those treated with OA and 18% of those receiving RT) to any of the two treatments in the first treatment phase in RCT2 were pooled together with posttreatment responders (OA = 51%, RT = 35%, Co = 26%) and nonresponders in the OA and RT/Co groups in RCT1, thus leading to a slight overestimation of the overall effect of OA in the total sample. Finally, while we found active treatment ingredients to work in the present study, it should be emphasized that nonspecific treatment factors, such as placebo effects and spontaneous remission, may also have had an influence across the extended evaluation period as contributing factors to the observed improvement levels in TMD pain intensity and frequency among participants.

The strength of the present study is the long-term follow-up of adolescents suffering from frequent TMD pain, and treated with standardized methods in two controlled trials and followed into young adulthood, with an acceptable response rate (69.5%).

## 5 | CONCLUSIONS

Due to the lack of long-term follow-up studies of treatment in adolescent TMD patients, the present study provides important information on treatment outcome effects over an extended follow-up period for these age groups. However, our findings and treatment methods need to be replicated by other clinical research groups, and in different settings, to further establish the validity and reliability of the present findings. The clear, and poorer, short- and long-term outcome for nonresponders to either RT or OA therapy in the first phase underlines the need to identify these more burdened individuals in clinical settings, but also to develop more effective methods to help them reduce their TMD pain. Although OA has been used in clinical practice as a standard method for TMD treatment in adolescents, despite weak empirical support based primarily on findings in adult populations, the present long-term study including adolescents with predominantly myofascial pain showed that such treatment has significant clinical value in reducing these complaints. Finally, there is a need for future research to evaluate the effects of treatment methods also focusing on other substantial problems in teenagers such as TMJ dysfunction and pain.

### CONFLICT OF INTEREST

The authors report no conflict of interest related to this study.

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