Effect of Shortened Dental Arch on Temporomandibular Joint Intra-articular Disorders

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Aims: To investigate whether a shortened dental arch (SDA), as identified by reduced posterior occlusal contacts, is a risk factor for the progression of temporomandibular joint (TMJ) intra-articular disorders (ID), as identified using imaging techniques. **Methods:** This multisite, prospective observational study with a mean follow-up period of 7.9 years had a sample of 345 participants with at least 1 temporomandibular disorder (TMD) diagnosis at baseline. SDA was defined as reduced occlusal posterior support due to lack of occlusal intercuspal contacts in the molar region on the left and/or right side. SDA was assessed at baseline and at follow-up with metalized Mylar Tape. The presence or absence of a TMJ ID and the specific TMJ ID diagnoses for baseline and follow-up images were established by a calibrated, blinded radiologist at each of three sites by using bilateral magnetic resonance imaging for soft tissue imaging for disc displacement and by bilateral multidetector computed tomography or cone beam computed tomography for hard tissue imaging for degenerative joint diseases. Wilcoxon rank sum test and linear regression analyses were used to test for an impact of SDA on TMJ ID status. **Results**: At baseline, TMJ ID status of either side was not significantly affected by the presence of SDA on the ipsilateral or contralateral side of the jaw (all $P > .05$). Furthermore, the presence or absence of SDA at baseline was also not a significant predictor for progression of the TMJ ID status between baseline and follow-up (all $P > .05$). **Conclusion:** The findings of this study suggest that there is no significant effect of SDA on progression of TMJ ID. *J Oral Facial Pain Headache 2018;32: 329–337. doi: 10.11607/ofph.1910*

Keywords: *intra-articular disorders, observational study, risk factor, shortened dental arch, temporomandibular joint*

Temporomandibular disorders (TMD) are characterized by pain in the temporomandibular joints (TMJ) and/or the masticatory muscles, noises in the joint, or dysfunction and functional limitations, such as impaired jaw movements.[1,2] Traditionally, the different TMJ intra-articular disorders (IDs) have been thought to follow a longitudinal progression from normal joint structure, to disc displacement with reduction (DDwR), to disc displacement without reduction (DDw/oR), and then to degenerative joint disease (DJD),[3–5] which can be further subclassified as Grade 1 DJD or Grade 2 DJD based on the level of severity.[6,7] Several factors may facilitate this progression, including overt macrotrauma or microtrauma from oral habits. Trauma from occlusal factors is also considered an important risk factor.[8–10] The investigation of IDs is of special interest since occlusal-based treatment approaches for IDs, including occlusal adjustments, are commonly employed.[11,12]

Historically, tooth loss in the posterior dental arch has been regarded as a risk factor for structural changes in the TMJ.[13] The loss of posterior support and a resulting reduction of the vertical dimension of occlusion have been thought to overload the TMJs and lead to an ID. Whether missing posterior teeth—a condition described as a shortened dental arch (SDA)[14]—is related to TMD, and specifically to ID, has been investigated in a large number of studies with inconsistent results. Several studies have reported an association between SDA and ID, with a higher prevalence of DD and DJD in subjects with SDA.[9,15,16]

In addition, replacement of missing posterior teeth has been reported to decrease the amplitude of clicking, a clinical sign of DDwR.[17] Also, experimental reduction of posterior occlusal contacts results in cranial movement of the condyle,[18] which could lead to adverse changes in TMJ loading and subsequent structural changes that could in turn lead to DD or DJD. Conversely, other studies have reported no association between ID and SDA,[19–22] including a study that reported the presence of TMJ sounds did not differ substantially relative to posterior occlusal support.[23] In another study specifically investigating joint loading with SDA, no evidence for increased TMJ loading was observed.[24]

These studies have several methodologic limitations that may account for the contradictory findings. Most of the studies relied on self-report and/or clinical examination to assess for ID despite the fact that definitive diagnoses for DD and DJD require TMJ magnetic resonance imaging (MRI) and TMJ computed tomography (CT), respectively.[25] Furthermore, the majority of the studies were cross-sectional, which precludes inferences regarding cause and effect. There are also shortcomings in the determination of SDA, as most investigations have reported only missing teeth; however, if teeth are present but do not contact the teeth in the opposing dental arch, they still do not contribute to occlusal support. Therefore, SDA is most accurately assessed by measurement of contacting posterior teeth.

The aim of this study was to investigate whether SDA, as identified by reduced posterior occlusal contacts, is a risk factor for the progression of TMJ ID, as identified using imaging techniques.

Materials and Methods

Subjects, Study Design, and Setting

This multisite, prospective observational study conformed with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for human observational investigations.[26] Baseline and follow-up data came from the Validation and TMJ Impact Projects, respectively, both conducted at the University of Minnesota, the University of Washington, and the University at Buffalo.[7,27] At baseline, subjects aged 18 to 70 years old were recruited from two sources: direct referrals from local health care providers to the respective university-based TMD centers (ie, clinic cases) and from responses to community advertisements (ie, community controls and cases). A total of 724 participants were recruited as a convenience sample between August 2003 and September 2006. Participants diagnosed with comorbid systemic pain conditions (ie, chondromatosis, fibromyalgia, or rheumatoid arthritis; n = 19) were excluded, resulting in 705 participants. Funding for subject recall for the TMJ Impact Project was approved for 400 subjects, and a total of 401 were seen for follow-up assessment with a mean follow-up of 7.9 years (standard deviation [SD]: 0.8; range: 5.8 to 10 years).[7] The 401 participants were a convenience sample of the 594 participants in the Validation Project who gave permission to be contacted for a future study. Compensation for participation was $200 at baseline and at follow-up. Baseline community and clinic cases with at least one TMD diagnosis (any TMD pain–related or TMJ ID diagnosis) were selected to allow for a full spectrum of cases. The final sample size was 345 participants. For more details about study design, participant recruitment, and examination, see Schiffman et al.[7,27]

This research was conducted in accordance with accepted ethical standards for research practice and was approved by the Institutional Review Board at each of the three study sites.[27] Written informed consent was obtained from all participants prior to their enrollment.

Overview of Measurements

Demographic characteristics of the study population, including, age, gender, education, and income, were collected at baseline using questionnaires. Measures for oral behavioral and psychosocial status were described in detail in the overview of the Validation Project.[27] These included measures for depression (Depression and Vegetative Symptoms subscale), somatization (Nonspecific Physical Symptoms subscale), and anxiety from the revised version of the Symptom Checklist 90 (SCL-90-R)[28] and characteristic pain intensity from the 7-item Graded Chronic Pain Scale (GCPS).[29] Additional psychosocial and behavioral assessments were perceived stress from the 10-item Perceived Stress Scale (PSS-10)[30] and oral behaviors from the 21-item Oral Behaviors Checklist (OBC).[31] The results of the full range of assessments provide a complete description of the study population; however, only age and gender are included in the present analyses.

Assessment of SDA

SDA was defined as no occlusal intercuspal contacts in the molar region on the left and/or right side, adopted from the definition by Käyser.[14] Specifically, all molars were either *(1)* missing and not replaced; or *(2)* when present or replaced, did not have any occlusal intercuspal contact with the teeth of the opposing arch. Occlusal intercuspal contacts were assessed at baseline and follow-up by one of two calibrated examiners at each site using metalized Mylar Tape (shimstock) with 8-µm thickness for each individual occluding pair around the dental arch. After the Mylar strip was inserted between the pair of teeth, participants were instructed: "Close firmly on your back teeth in your best bite and hold until I say open." After teeth closure, the examiner pulled on the Mylar strip to determine if it held or slipped free. This method has good reliability for identifying posterior occlusal contacts.[32] Examiners from all three study sites were brought together for training and calibration for this assessment.[27]

Image Acquisition Protocols

All participants had bilateral TMJ MRI scans at baseline and follow-up for soft tissue imaging. Multidetector CT (MDCT) was used for hard tissue imaging at baseline, and cone beam CT (CBCT) at follow-up.[7,33] MRI scans were acquired during closed and open mouth positions by using a TMJ surface coil. At least six slices of each joint were obtained in sagittal and axially corrected coronal (closed mouth views only) views. The baseline MRI used 1.5T magnetic fields, and the follow-up used 3T. For MDCT and CBCT, at least 12 sections of each condyle (0.20-mm-thick slices) were generated in sagittal and axially corrected coronal views in the closed mouth position. CBCT has been shown to provide diagnostic information equivalent to MDCT with a substantially lower radiation dose and is currently considered the preferred imaging modality for the TMJ in dentistry.[34,35] Further details on the image acquisition protocols, as well as the reliability of the baseline and follow-up radiologists, have been previously reported.[7,33]

Diagnosis of TMD

Baseline pain-related TMD diagnoses, when present, were based on the consensus of two criterion examiners at each of the three sites applying a comprehensive protocol that included a semi-structured interview, review of questionnaires, and clinical examination.[27] The clinical examination protocol was composed of all the measures as operationalized in the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) and several previously described examination procedures.[36] All six calibrated examiners who rendered these consensus-based diagnoses were experts in TMD and orofacial pain.

The presence or absence of an ID and the specific TMJ-based diagnoses were established for baseline and follow-up images by three calibrated, blinded radiologists who used a consensus-based diagnostic protocol for each site. Diagnoses of DD and DJD were derived from TMJ MRI and CT, respectively, without considering the presence or absence of clinical symptoms. Inter-rater reliability of this assessment protocol was found to be good to excellent, with kappas of .73 for DD and .76 for DJD. More specifics of the radiologists' reliability assessment and the assessment protocol have been reported.[7] The diagnostic criteria for the stages of DD and DJD applied in this study are shown in Table 1. For this study, the "normal" and "indeterminate" stages (ie, when only one of two criteria for the posterior band and intermediate zone required for the stage "normal" have been confirmed) were combined. Progression was defined as an increase in at least one stage in this model from baseline to follow-up: Normal → DDwR → DDw/oR → DJD Grade 1 → DJD Grade 2. Reversal was a decrease in at least one stage in this model.

Data Analyses

The approach to investigate whether SDA is a risk factor for progression of TMJ ID involved several steps. First, sociodemographic, socioeconomic, behavioral, psychosocial, and pain characteristics of the study sample at baseline were assessed using mean and standard deviation (SD) values for continuous measures and frequencies and proportions for ordinal and categorical measures. Distribution of the different diagnoses regarding TMJ ID status was determined for each joint by side. Joint-specific findings were compared statistically using Wilcoxon signed rank test to assess whether baseline intra-articular status was more severe in one of the sides. A tetrachoric correlation coefficient was calculated to assess the association of SDA prevalence between the sides. Guidelines suggest that coefficients of $r = .1$ are considered small, $r = .3$ are medium, and $r = .5$ are large.[37]

Second, the proportion of participants with SDAs for each joint-specific intra-articular state was calculated at baseline and at follow-up to test whether SDA at baseline was associated with a more severe TMJ ID. Statistical significance was tested by using Wilcoxon rank-sum test for each joint and assessment. Furthermore, the proportions of participants with progression, no change, or reversal in the TMJ ID status between baseline and follow-up were determined for each joint separately and then stratified for right- and left-sided occlusal status.

Third, whether SDA on either side was related to a more advanced TMJ ID state was tested with linear regression analyses. These analyses allowed assessment of the strength of the relationship between the anticipated risk factor—SDA—and the progression of TMJ ID. For these models, intra-articular status as the criterion variable was considered quasilinear; ie, the increase in severity between each intra-articular status (Normal → DDwR → DDw/oR → DJD Grade 1 → DJD Grade 2) was assumed to be approximately equal, in accordance with a previous study.[38] In the first model, association between SDA and intra-articular status at baseline was tested. In the second model, the effect of SDA at baseline on

Table 1 Diagnostic Criteria for Disc Displacement (DD) and Degenerative Joint Disease (DJD)

	Criteria		
Stages of DD	**Closed mouth position**		**Open mouth position**
Normal disc position (including indeterminate)	Posterior band is between 11:30 and 12:30 o'clock positions and/or intermediate zone is located between the condyle and the articular eminence		Intermediate zone is located between the condyle and the articular eminence
Disc displacement with reduction	Posterior band is located anterior to the 11:30 o'clock position and intermediate zone is located anterior to the condyle		Same as normal
Disc displacement without reduction	Posterior band is located anterior to the 11:30 o'clock position and intermediate zone is located anterior to the condyle.		Persistent disc displacement
Stages of DJD			
Normal (including indeterminate)	No osseous changes or localized sclerosis and/or flattening		
Grade 1 DJD	1. Osteophyte	< 2 mm measured from tip of condyle to expected contour of condyle	
	2. Erosion	< 2 mm in depth and width	
	3. Cyst	< 2 mm in depth and width	
Grade 2 DJD	1. Osteophyte	≥ 2 mm	
	2. Erosion	≥ 2 mm; or special case is when the whole condylar head is eroded	
	3. Cyst	≥ 2 mm	
	4. Combination	≥ 2 signs of Grade 1 DJD	

Adapted from Ahmad and Schiffman[6] and from Schiffman et al.[7]

intra-articular status at follow-up was assessed while statistically controlling for the intra-articular status at baseline; that is, testing was done for an effect of SDA on progression of TMJ ID. For this model, participants with the most severe intra-articular status (end-stage DJD Grade 2) at baseline were excluded for the joint-specific analyses to allow for a progression of the disorder. The third model was identical to the second model, but only participants without a change in SDA between both assessments were included; this provided a group with SDA at the beginning and the end of this longitudinal study. Models are presented with and without adjustments for age and gender.

All data on the ID status of both joints and SDA of both sides were complete in 337 subjects (97.7%). Only four subjects had missing information on the intra-articular status of the right joint, and five for the left one. Data for occlusal posterior support were incomplete in one participant for the right side and two participants for the left side. Subjects with incomplete information were excluded from the analyses for those particular variables.

All analyses were performed using the statistical software package STATA (Stata Statistical Software: Release 13.1; StataCorp LP), with the probability of a type I error set at the .05 level without adjustment for multiple comparisons.

Results

Baseline Characteristics of Participants

Participants were predominantly female (85.8%), and mean (± SD) age at baseline was 37.9 ± 12.9 years. Information on demographic characteristics, oral behavioral and psychosocial statuses, and pain intensity level is presented in Table 2. Based on TMJ imaging, about a fifth of the participants' right and left joints were classified as normal (Table 2). Prevalence of ID at baseline for the right TMJ was lowest for DDw/oR (7.3%) and highest for DDwR (30.8%), and for the left TMJ was lowest for DDw/oR (5.9%) and highest for DJD Grade 2 (31.5%), respectively, with no significant difference between the sides (P = .954). SDA was observed slightly more often in the participants' left-sided occlusion (11.7%) than on the right side (8.7%; Table 2). Findings for SDA were highly correlated between both sides (r = .66, P < .001), with 4.4% of the participants presenting with bilateral SDA.

TMJ Intra-articular Status and SDA

In the side-specific analysis, the proportion of participants with an SDA on the right side at baseline ranged from 6.7% in participants with DJD Grade 2 to 12.0% for DDw/oR, and for the left side, SDA ranged from 0.0% for DDw/oR to 13.1% for DDwR (Table 3). Even though the proportion slightly varied with respect to TMJ intra-articular status, no pattern of higher SDA values in more severe status was observed (both P > .05).

Findings at follow-up on the right side for SDA differed only marginally from those at baseline (Table 3). In contrast, the proportion of participants with SDA substantially increased from baseline to follow-up, especially in participants with DDw/oR or DJD Grade 1 in the left TMJ. Again, there was no association between severity of TMJ intra-articular status and proportion of participants with SDA for either side (both P > .05).

When findings at baseline and follow-up were compared without considering occlusal status, a progression in the right TMJ was observed in 25.9% of participants and in the left TMJ in 20.6%. Overall, a reversal was observed in the right TMJ in 19.4% of the participants and in the left TMJ in 17.1%. However, change in TMJ intra-articular status between baseline and follow-up was not associated with baseline occlusal status of the right or left side (all $P > .05$; Table 4).

Risk for Progression in TMJ Intra-articular Status

At baseline, TMJ intra-articular status of both sides was not significantly associated with the presence of SDA on the ipsilateral or contralateral side of the jaw (all $P > .05$; Model 1; Table 5). However, SDA on the right side was associated with a reduced severity of ID status by −0.25 stages for the right TMJ and by −0.29 stages for the left TMJ. This indicates that when SDA is present, the ID is less severe by an average of one stage in one out of four participants, although these findings were not statistically significant (both $P > .05$). These results did not change substantially after adjusting for age and gender.

The presence or absence of SDA at baseline was not a significant predictor for progression of TMJ ID status between baseline and follow-up (all $P > .05$; Model 2; Table 5). SDA of the right side at baseline reduced the severity of the ID status of the right TMJ during the study period by an average of −0.41 stages, although this observation was not statistically significant ($P = .183$). The presence of SDA on the right side had no effect on the left TMJ ($P = .807$). In contrast, missing posterior support on the left side increased the severity of the ID status in both joints in the unadjusted and the adjusted analyses by an average of a quarter stage, but the effect was not significant (all $P > .05$).

The third model included only participants with SDA at baseline and at follow-up, and these findings were slightly different (Model 3; Table 5). SDA on the right side was related to a progression of ID status in both joints (right: 0.30 stages, left: 0.70 stages), while an SDA of the left side improved the ID status in both joints (right: −0.17 stages, left: −0.55 stages). However, none of these effects were statistically significant (all $P > .05$). The adjusted analysis did not reveal substantially different findings.

Table 2 Participant Characteristics at Baseline

	Participants (N = 345)	
Age (y), mean (SD)	37.9 (12.9)	
Gender, n (%)		
Male	49 (14.2)	
Female	296 (85.8)	
Education,[a] n (%)		
No college	52 (15.1)	
≥ 1 y of college	292 (84.9)	
Annual household income,[b] n (%)		
< \$50,000	186 (54.6)	
\$50,000–\$79,999	88 (25.8)	
≥ \$80,000	67 (19.7)	
Oral behaviors, mean ± SD		
OBC sum score	24.2 (8.6)	
Perceived stress, mean ± SD		
PSS-10 sum score	12.9 (6.3)	
Nonspecific physical symptoms (somatization),[c] n (%)		
Low	202 (58.7)	
Moderate	96 (27.9)	
Severe	46 (13.4)	
Depression and vegetative symptoms,[d] n (%)		
Low	233 (67.7)	
Moderate	80 (23.3)	
Severe	31 (9.0)	
Anxiety,[e] n (%)		
Low	256 (74.4)	
Moderate	64 (18.6)	
Severe	24 (7.0)	
Graded chronic pain, mean ± SD		
Characteristic pain intensity	39.6 (27.3)	
	Right side	**Left side**
TMJ intra-articular status,[f] n (%)		
Normal	59 (17.3)	68 (20.0)
DDwR	105 (30.8)	99 (29.1)
DDw/oR	25 (7.3)	20 (5.9)
DJD Grade 1	62 (18.2)	46 (13.5)
DJD Grade 2	90 (26.4)	107 (31.5)
Occlusal status (SDA),[g] n (%)		
Missing molar support	30 (8.7)	40 (11.7)

SD = standard deviation; OBC = Oral Behaviors Checklist; PSS = Perceived Stress Scale; DDwR = disc displacement with reduction; DDW/woR = disc displacement without reduction; DJD = degenerative joint disease.
[a]One missing value for education.
[b]Four missing values for income.
[c]One missing value for nonspecific physical symptoms.
[d]One missing value for depression and vegetative symptoms.
[e]One missing value for anxiety.
[f]Four missing values for TMJ intra-articular status of the right TMJ and five missing values for the left TMJ.
[g]One missing value for occlusal status of the right jaw and two missing values for the left jaw.

Discussion

This is the first prospective study (with an average follow-up of 7.9 years) to investigate the risk of SDA on progression of TMJ ID using reliable and valid assessement with MRI for soft tissue imaging of DD and CT/CBCT for hard tissue imaging of DJD. The findings from this study suggest that SDA is not a significant risk factor for the progression of TMJ ID.

If SDA had an effect on TMJ ID progression, it would be expected that an SDA on the right side should be related to the same changes in the ipsilateral and the contralateral TMJ as an SDA on the left side. In both regression models using the longitudinal data, regression coefficients for SDA on the right side differed not only in the absolute values, but also in the

Table 3 Proportion of Participants with Shortened Dental Arch (SDA) for Each TMJ Intra-articular Status at Baseline and Follow-up

	Participants % (no. with SDA/no. with TMJ status)			
	Baseline		Follow-up	
TMJ intra-articular status	Right side n = 340	Left side n = 338	Right side n = 342	Left side n = 342
Normal	8.5 (5/59)	11.8 (8/68)	11.3 (7/62)	11.9 (8/67)
Disc displacement with reduction	10.6 (11/104)	13.1 (13/99)	9.4 (9/96)	6.6 (6/1)
Disc displacement without reduction	12.0 (3/25)	0.0 (0/20)	11.5 (3/26)	17.6 (3/17)
Degenerative joint disease, Grade 1	8.1 (5/62)	10.9 (5/46)	8.8 (5/57)	16.7 (11/66)
Degenerative joint disease, Grade 2	6.7 (6/90)	12.4 (13/105)	5.9 (6/101)	11.9 (12/101)
P value[a]	.495	.957	.233	.495

[a]Based on Wilcoxon rank sum test.
Note: For baseline, denominators for each cell (no. of subjects with TMJ intra-articular status) are identical to Table 2.

Table 4 Proportion of Participants with Changes in TMJ Intra-articular Status Between Baseline and Follow-up for Each Joint and Stratified for Right- and Left-Sided Occlusal Status

	Right-sided occlusal status		Left-sided occlusal status	
Change in TMJ intra-articular status	Without SDA n = 309	With SDA n = 30	Without SDA n = 299	With SDA n = 39
Right TMJ				
Progression (%)	25.9	26.7	26.4	23.1
Without change (%)	56.0	43.3	53.5	61.5
Reversal (%)	18.1	30.0	20.1	15.4
P value[a]	.432		.899	
Left TMJ				
Progression (%)	20.7	23.3	20.4	25.6
Without change (%)	62.5	56.7	63.9	51.3
Reversal (%)	16.8	20.0	15.7	23.1
P value[a]	.846		.884	

[a]Based on Wilcoxon rank sum test; *P* value for statistical significance regarding presence of SDA (shortened dental arch).

direction regarding the effect on TMJ ID status on the ipsilateral and contralateral sides. This means that an SDA on one side would be protective for the ipsilateral TMJ, while an SDA on the other side would be detrimental for TMJ ID on the iplsilateral TMJ. This is not biologically plausible and is likely the result of statistical variation. Furthermore, none of the regression coefficients exceeded the value 1 (representing a progression of the TMJ ID by one stage [eg, from DDw/oR to DJD Grade 1]), which was considered clinically relevant, and none of the regression coefficients were statistically significant. In summary, there is no evidence from this study that SDA has any adverse or protective effects on the progression of TMJ ID.

Comparisons with previous reports are constrained, since this is the first prospective study to investigate the impact of SDA on progression of TMJ ID with state-of-the-art imaging. However, the baseline findings are consistent with some previous cross-sectional studies. Ciancaglini et al did not find an association between the number of missing occlusal units and the presence of clicking and crepitus joint noises (the clinical signs of DDwR and DJD, respectively).[20] Other studies have reported no association between loss of molars in supporting zones and TMJ changes identified with panoramic radiographs[19] or DD assessed by means of arthrograms.[21] One prospective study with a 9-year follow-up assessed the impact of SDA on TMD, but did not find an effect on the presence of clicking and crepitus joint noises.[22]

Others have reported contrary findings. Dulcic et al examined partially edentulous subjects with either occlusal contact in at least one but not all four supporting zones (Eichner class II) or no contact in any zone (Eichner class III).[15] Subjects in the group with more contacting zones had more DD but less DJD than subjects in the group without contacts. This would correspond to a higher progression of TMJ ID in subjects with bilateral SDA; however, this study did not include a control group with contact in all supporting zones (Eichner class I) and determined the TMJ status with only clinical findings. Tallents et al reported a slightly higher prevalence of missing posterior teeth in TMD patients with DD compared to asymptomatic controls with normal MRI findings.[16] However, when only controls or TMD patients were

Table 5 Linear Regression Models for Association Between Occlusal Status at Baseline and TMJ Intra-articular Status Separately for Each Joint (Progression: Normal → DDwR → DDw/oR → DJD Grade 1 → DJD Grade 2)

Dependent variable/Independent variable	Coefficient (95% CI)	*P* value
Right TMJ		
Model 1: TMJ intra-articular status at baseline (n = 338)		
SDA right side	−0.25 (−0.86; 0.36)	.424
SDA left side	0.12 (−0.43; 0.66)	.673
With adjustments for age and gender		
SDA right side	−0.26 (−0.87; 0.35)	.397
SDA left side	0.00 (−0.56; 0.55)	.992
Age	0.01 (0.00; 0.03)	.061
Gender	0.08 (−0.38; 0.55)	.723
Model 2: TMJ intra-articular status at follow-up[a] (n = 250)		
Normal → DDwR → DDw/oR → DJD Grade 1 → DJD Grade 2		
SDA right side	−0.41 (−1.02; 0.20)	.183
SDA left side	0.20 (−0.38; 0.77)	.507
With adjustments for age and gender		
SDA right side	−0.33 (−0.94; 0.27)	.280
SDA left side	0.26 (−0.32; 0.84)	.380
Age	0.00 (−0.02; 0.01)	.555
Gender	0.52 (0.08; 0.96)	.021
Model 3: TMJ intra-articular status at follow-up (same occlusal status at baseline and follow-up)[a] (n = 199)		
SDA right side	0.30 (−1.04; 1.64)	.657
SDA left side	−0.17 (−1.35; 1.00)	.773
With adjustments for age and gender		
SDA right side	0.29 (−1.07; 1.65)	.674
SDA left side	−0.07 (−1.25; 1.10)	.904
Age	0.00 (−0.02; 0.01)	.931
Gender	0.55 (−0.02; 1.12)	.059
Left TMJ		
Model 1: TMJ intra-articular status at baseline (n = 337)		
SDA right side	−0.29 (−0.93; 0.35)	.376
SDA left side	0.08 (−0.49; 0.65)	.781
With adjustments for age and gender		
SDA right side	−0.26 (−0.89; 0.36)	.404
SDA left side	−0.13 (−0.70; 0.43)	.640
Age	0.03 (0.01; 0.04)	< .001
Gender	0.84 (0.36; 1.32)	.001
Model 2: TMJ intra-articular status at follow-up[a] (n = 232)		
SDA right side	0.07 (−0.49; 0.63)	.807
SDA left side	0.23 (−0.30; 0.76)	.397
With adjustments for age and gender		
SDA right side	0.08 (−0.49; 0.65)	.788
SDA left side	0.24 (−0.30; 0.79)	.382
Age	0.00 (−0.01; 0.01)	.784
Gender	−0.01 (−0.43; 0.40)	.943
Model 3: TMJ intra-articular status at follow-up (same occlusal status at baseline and follow-up)[a] (n = 182)		
SDA right side	0.70 (−0.28; 1.69)	.161
SDA left side	−0.55 (−1.41; 0.31)	.205
With adjustments for age and gender		
SDA right side	0.68 (−0.33; 1.69)	.188
SDA left side	−0.56 (−1.43; 0.31)	.205
Age	0.00 (−0.01; 0.02)	.779
Gender	0.04 (−0.45; 0.53)	.865

[a]Included only subjects without DJD Grade 2 at baseline; statistically controlled for baseline status. DDwR = disc displacement with reduction; DDw/oR = disc displacement without reduction; DJD = degenerative joint disease; SDA = shortened dental arch; CI = confidence interval.

assessed, no association between MRI findings of DD and missing posterior teeth was observed. Finally, Pullinger et al reported that the number of missing molars was associated with DDwR and DJD.[9] However, for a clinically relevant effect (odds ratio of at least 2), five or more posterior teeth had to be missing, which is a substantial number. Furthermore, the number of missing teeth cannot be easily translated into the presence of missing posterior support, and the cross-sectional design limits conclusions.

SDA was operationalized as missing posterior support due to no occlusal intercuspal contacts in the molar region. These contacts were assessed with Shimstock of 8-μm thickness using a valid and reliable method.[32] Thicker foils might in some cases indicate an occlusal intercuspal contact, resulting in a lower proportion of subjects with an SDA due to an increase in false positives, which is not desirable. The definition of SDA in this study differs from those applied in other studies. Alternatively, SDA can be defined just as the absence of posterior teeth,[14,39] sometimes assessed from casts[9] or panoramic radiographs,[19] limiting the comparability to the present study. However, it is assumed that the important biomechanical feature is the presence or absence of contact and not whether the teeth are missing. Missing contacts alone result in cranial movement of the condyle,[18] which could lead to adverse changes in TMJ loading and subsequent structural changes leading to DD or DJD. Such a cranial movement of the condyle can occur during chewing, swallowing, or bruxism, whereas the latter can have a higher load with more adverse potential on the TMJs. Oral behaviors, including clenching and grinding of the teeth when asleep or during waking hours, were assessed in the Validation and TMJ Impact Projects using the OBC self-report questionnaire.[31] However, germane to this discussion, the OBC only assesses the subject's awareness of the frequency of their bruxism—not the intensity and duration. Therefore, it is not possible to accurately estimate the load on the TMJ with this self-report instrument. For this reason, bruxism was not included as a predictor in the regression models. Also, subjects with SDA might differ in the way they chew: Without molars, subjects have to chew in the premolar region, whereas subjects with molars but without occlusal intercuspal contact could potentially chew in the molar region as well. The preferred location of chewing was not assessed in the study; however, since SDA had no effect on TMJ ID, further variables such as bruxism or chewing location would probably not significantly affect the main finding of this study. Finally, no subgroup analysis for those subjects with all molars missing was performed due to insufficient sample size.

Strengths of this study included the large sample size, which allowed high precision for estimation of effects, and the fact that the diagnoses of TMJ ID were based on interpretation of TMJ MRI and CT scans by three calibrated, blinded radiologists with good to excellent reliability. Furthermore, the prospective design of the study allowed for investigating the cause-effect relationship between SDA and TMJ ID. Finally, an additional analysis was performed to test whether the findings would change when more stringent criteria for the risk factor were applied; that is, presence of SDA at the beginning and the end of the longitudinal study. This analysis also supported the conclusion that SDA has no effect on TMJ ID, although the 95% confidence intervals (CI) were wide due to the small sample size, suggesting some caution is needed in interpretation.

While the study sample was not representative of the general population, it does provide participants with the full spectrum of TMD by using a convenience sample from both clinical and community sources. Participants were selected based on methodologic considerations of the Validation Project, which ensured a sufficient number of participants for each of the TMD diagnoses to improve generalizability of results,[27] and it is not expected that findings would substantially differ if random samples had been used.

The clinical implication of this study is that the lack of posterior tooth support does not cause progression of TMJ ID. Given that TMD appliance therapy, especially mandibular anterior repositioning appliances and sleep apnea appliances, can cause SDA (lack of posterior molar contacts), the present findings suggest that treatment of this malocclusion may not be needed to prevent progression of TMJ ID. The same can be said of patients that present to their dentist with SDA occurring in their natural occlusion or their acquired occlusion due to lack of—or prior—dental treatment. However, the results of this study do not suggest that replacing missing molars, or lack of posterior tooth contact, should not be treated for dental reasons.

Conclusions

Findings of this study suggest that there is no significant effect of SDA on progression of TMJ ID. Accordingly, there is no justification for replacing missing molars or restoring missing posterior tooth contacts to prevent the progression of TMJ ID.

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