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SCIENTIFIC SECTION

Longitudinal study on TMJ disk status and its effect on mandibular growth

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Objective: This longitudinal study assessed the potential contribution of temporomandibular joint (TMJ) disk status over mandibular linear and angular changes.

Design: Cohort study.

Setting: Edmonton, Alberta, Canada.

Participants: Seventy-three adolescent subjects attending TMJ or orthodontic clinics with or without TMJ disk abnormality were followed during a mean 3 years 7 months. From this sample 39 subjects underwent orthodontic treatment.

Methods: Disk displacement and disk length measurements taken from MRIs were utilized to evaluate the TMJ disk status. Mandibular changes were quantified from cephalometric radiographs by superimposing the mandible around the internal cortex of the posterior wall of the mandibular symphysis. Fishman's skeletal maturation system was used to calculate the percentage of mandibular growth remaining during the follow-up. This expected mandibular growth was factored out through a statistical normalization process applied to the actual difference between the initial and final mandibular measurements. In addition, previous orthodontic treatment was also considered for the analysis. A multiple analysis of variance (MANOVA) was used to evaluate interaction between the independent variables (TMJ disk status and previous orthodontic treatment) over the dependent variables (mandibular ramus, mandibular body, mandibular length and gonial angle measurements).

Results: No significant contribution was found of any of the evaluated variables or its interactions over the mandibular measurements.

Conclusions: No evidence was found of TMJ disk abnormality as an associated significant factor with mandibular dimensional changes. The findings have to be evaluated with caution because of some limitations identified in this study.

Key words: Temporomandibular joint dysfunction syndrome, growth and development, mandible

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Introduction

Temporomandibular joint (TMJ) internal derangement is one of the conditions associated with TMJ disorders. Although TMJ clinical examination is still considered to be one of the most important criteria to diagnose TMJ internal derangement, use of auxiliary radiological exams is also considered primordial. A trend of increased clinically determined TMJ sounds and age has been reported in cross-sectional studies,[1–8] but has not been confirmed in longitudinal studies.[9–11] Use of radiological techniques to complement the clinical examination showed an increase in the prevalence of TMJ internal disorders.[12–17] Differences reported between symptomatic and asymptomatic patients' prevalence could be explained due to the sample selection process.

Several studies have evaluated transversally the association between TMJ internal derangement and craniofacial growth. Temporomandibular joint internal derangement has been associated with reduced ramus height,[4,18–22] decreased mandibular body length,[4,21,22] reduced posterior total facial height without an associated increased anterior facial height,[20–22] palatal[20,21] and mandibular[20–22] planes more convergent in the posterior region, vertically reduced maxillary molar position,[20,21] reduced size of the anterior[21,22] and posterior cranial bases,[21] and uprighting of the lower incisor relative to the mandibular plane.[21]

Based on the published literature it seems that TMJ disk status is associated with altered craniofacial characteristics. To our knowledge only one study[23] in adolescents has previously evaluated the longitudinal association between TMJ disk status and altered mandibular growth. This study showed that TMJ disk status was associated with reduced forward growth of the maxillary and the mandibular body as well as

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reduced downward growth of the mandibular ramus. However, the magnitude of these associations could only explain 10% of the alterations.

The above-mentioned study did not quantify changes in mandibular measurements but only mandibular spatial positional changes; therefore the present study was designed to evaluate the influence of TMJ disk status on mandibular measurement changes in a longitudinal sample of adolescents. It was expected that the current approach will shed more light on the long-term effect of TMJ disk displacement on mandibular growth.

Materials and methods

Sample characteristics

The present longitudinal study was a follow-up from a previously reported longitudinal sample of 194 adolescent subjects (119 females and 75 males) used to evaluate the association of TMJ disk status with craniofacial morphology.[20] These subjects were seeking orthodontic treatment and consented to lateral cephalograms and TMJ MRIs regardless of TMJ status.[23] Ethical approval was obtained from the Ethics Board of the University of Alberta. The group consisted of subjects with and without clinically detectable TMJ signs and symptoms. Descriptive data can be found in Table 1. Data such as race and socioeconomic status were not available. Of these subjects, 73 (46 females and 27 males) had the T1 (initial evaluation) and T2 (final evaluation) required radiographic records (lateral cephalogram and hand-wrist X-ray) for the present study. Of these, 39 subjects (20 females and 19 males) underwent orthodontic treatment during the study period. Mean follow-up time between initial (12.97 years, SD 1.83 years) and final (16.61 years, SD 2.14 years) records was 43.61 months. Reasons for lost to follow-up between T1 and T2 are summarized in Figure 1.

TMJ disk status

Bilateral closed mouth sagittal sections were obtained perpendicular to the long axis of the condylar axis, and coronal images were obtained parallel to the condylar long axis. The technique for quantitative analysis of MRI disk status used in this study was reported and validated by Nebbe *et al*.[24] The MRI evaluator was blinded to patient clinical symptom status. The researcher was blinded to the MRI scan when measuring mandibular variables, and was blinded to previous orthodontic treatment. The cephalograms were coded for blinding. In summary, a single weighted score based on the variability of all disk displacement and disk length measurements for each joint was calculated. A qualitative approach for diagnosing TMJ disk status has proven to be unreliable.[25]

Mandibular growth

Closed mouth lateral cephalometric radiographs were obtained. Open mouth lateral cephalometric radiographs were also acquired to accurately determine the shape of the head of the condyle. Mandibular changes were considered superimposing the mandibles around the internal cortex of the posterior wall of the mandibular symphysis.[26] By so doing, true linear or angular measurements could be calculated once mandibular spatial changes were factored out. Representative cephalometric points (Figure 2) in the mandible (Co, Go, Pg and Me) were traced twice by a single researcher with a month between each time point. Mandibular ramus (Co−Go), mandibular body (Go−Me), mandibular length (Co−Pg), and gonial angle (CoGo^GoMe) were used. A customized computer program was developed (Kent West; Crushersoft) which permitted the automatic calculation of the distances and angles between the traced points.

Table 1 Numbers, age and sex of patients at T1 (initial evaluation) and T2 (final evaluation).

	Number of cases	Minimum, year	Maximum, year	Range, year	Mean, year	SD, years
T1 (total)	73	9.06	16.86	7.80	12.97	1.83
T1 (females)	52	9.06	16.64	7.58	13.01	1.74
T1 (males)	27	9.58	16.86	7.28	12.90	1.99
T2	73	10.14	20.64	10.50	16.61	2.14
T2 (females)	52	10.14	20.64	10.50	16.72	2.03
T2 (males)	27	12.19	19.86	7.67	16.42	2.33
T1−T2	73	1.08	5.25	4.17	3.63	1.09
T1−T2 (females)	52	1.08	5.25	4.17	3.71	1.10
T1−T2 (males)	27	1.16	5.00	3.83	3.52	1.10

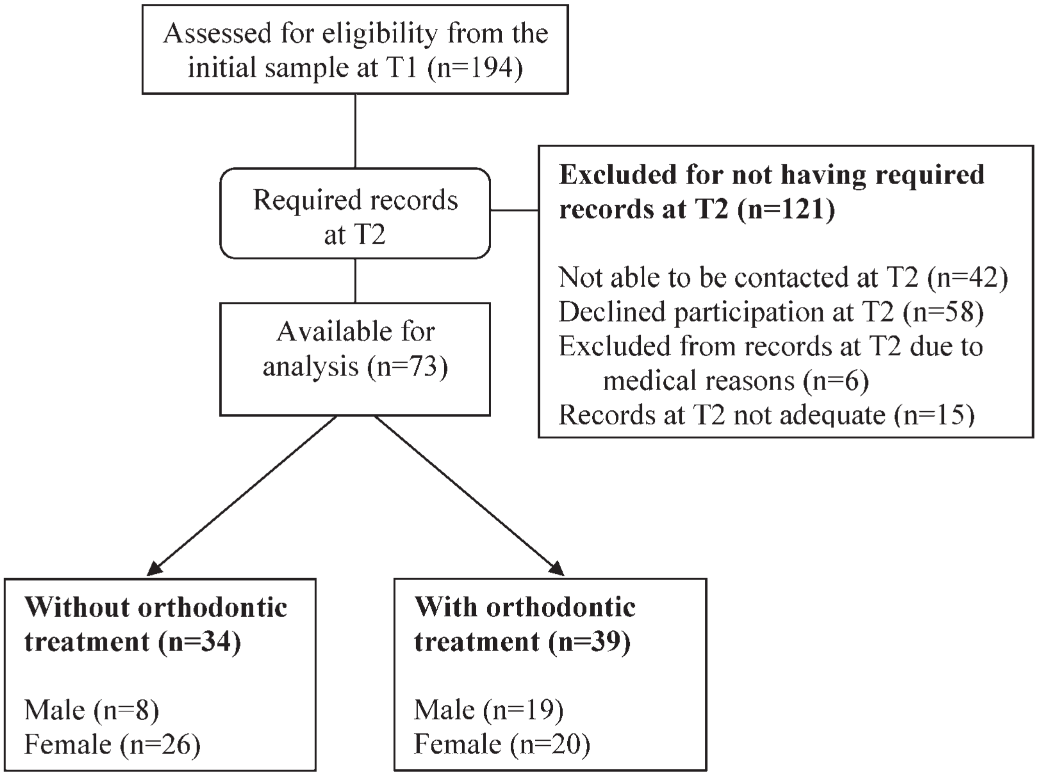

Figure 1 Patient flowchart: T1=initial evaluation; T2=final evaluation

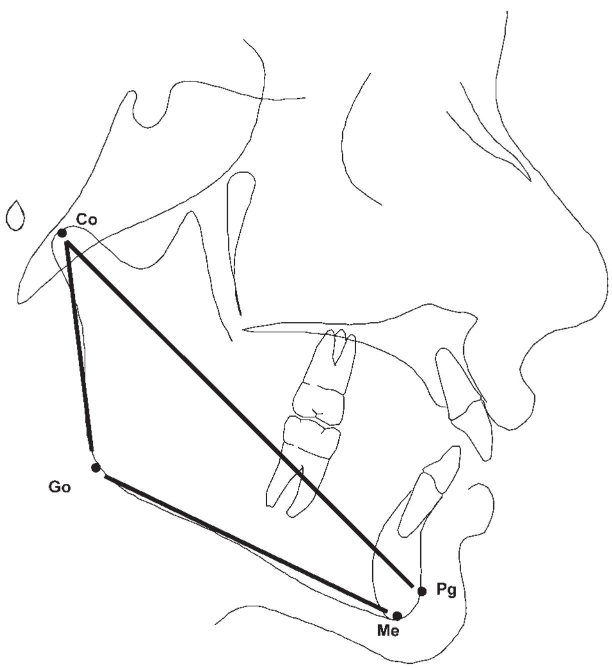

Figure 2 Cephalometric tracing of representative points in the mandible (Co, Go, Pg and Me): Co–Go=mandibular ramus length; Co–Pg=mandibular length; Go–Me=mandibular body; Co–Go–Me=gonial angle

Skeletal maturation and amount of mandibular growth remaining (MdGr)

Age, sex and time between X-rays were factored out using the Fishman maturation prediction method.[27] Skeletal maturation level (advanced, normal or delayed) and stage (relative position of the individual in the pubertal growth curve) were determined from hand-wrist X-rays. With this information, the percentage of mandibular growth expected to occur between the initial and final study points was determined. Expected mandibular growth was factored out through a normalization process (the individual expected growth was computed against the total mean expected growth and only the absolute value of this ratio was multiplied against the mandibular measurements) from the actual difference between T1 and T2 in the mandibular measurements.

Previous orthodontic treatment

Since orthodontic treatment may affect dental and possibly skeletal growth, previous orthodontic treatment was determined as a dichotomous variable.

Error of the method

Reliability of the TMJ disk status[28] and skeletal maturation prediction method have been previously reported.[23] The intra-examiner reliability was calculated for the measurements obtained from retracing six randomly selected cephalometric X-rays eight times. The intraclass correlation coefficient was between 0.992 and 0.999.

Statistical analysis

A multiple analysis of variance (MANOVA) was used to evaluate interaction between the independent variables (TMJ disk status and previous orthodontic treatment) over the dependent variables (normalized mandibular ramus, mandibular body, mandibular length and gonial angle) (Table 2). Only independent variables and their interactions that were significant in the MANOVA were planned to be considered for individual stepwise multiple linear regression analysis (SMLRA) to evaluate the contribution of the significant independent variables over the mandibular measurements.

Results

Results are shown in Table 2. No significant contribution of any of the independent variables (TMJ disk status and previous orthodontic treatment) or its interactions over the mandibular measurements were found with the MANOVA. Therefore no justification to perform a SMLRA was found.

Discussion

In the present study, TMJ disk abnormality was not significantly associated with changes in mandibular ramus, body and total length. A previous longitudinal publication[23] found that TMJ disk abnormality was only associated with a reduced spatial vertical position of Go; although the potential contribution of TMJ disk status abnormality was small (R^2<11.2%). If no significant change was found in the current study, it would be expected that Co would also be associated with a reduced vertical position so that the actual size of the mandibular ramus would not change as shown in our results. That would mean that there will be a mandibular ramus positional but not a dimensional difference between subjects with a normal compared to abnormal TMJ disk status. A possible explanation for the discrepancy is an artefact produced by the use of different superimposition areas. It should also be considered that positional alteration of the mandible may occur, which has not been studied in this paper (i.e. mandibular plane angle to cranial base or Frankfurt plane was not evaluated). Positional alteration in the mandible, as evaluated in the previous paper,[23] may explain some of the growth changes that have been reported previously.

No statistically significant change was found for the gonial angle. This finding was not surprising because the mandibular gonial angle responds to a multitude of craniofacial factors that affect the final shape and size of the craniofacial skeleton.

The primary limitation of this study was the lack of information regarding change in TMJ disk status between T1 and T2. The effect of progression of disk abnormality over time remains unknown. Perhaps progressive disk abnormality would be accompanied by altered condylar growth, whereas stable disk displacement and length alterations would not have further influence. It may be that there is a threshold of disk abnormality below which craniofacial growth is not 'significantly' affected; 'significant', however, is itself not currently defined.

An additional limitation of the present study may have been not to evaluate TMJ internal inflammation. Persistent inflammation with secondary disk abnormality may result in altered craniofacial growth. Therefore the resolution of inflammation regardless of disk status may allow resumption of normal growth. Evaluation of clinical signs in T2 and comparison with clinical signs in T1 would have been desirable but T2 clinical data were unfortunately not available.

Also the small sample size in each subgroup limited the statistical power of the tests. Attrition from the initial sample of more than 100 subjects made it impossible to gather a larger sample size for this study. Another point worth consideration is the sample origin and its implications for generalizations. This is a convenience sample of consecutive patients that attended certain clinical orthodontic and temporomandibular management practices in a defined time period. Therefore any generalization has to be made with caution.

Table 2 MANOVA analysing effects of independant variables (TMJ disk status and previous orthodontic treatment) over dependant variables (mandibular ramus, mandibular body, mandibular length and gonial angle).

	Value	*F*	Sig. (*P* value)
TMJ disk status	0.969	0.519	0.722
Previous orthodontic treatment	0.914	1.549	0.198
Interaction of both	0.995	0.091	0.985

Although Fishman's prediction method has shown to be the best available method to predict craniofacial growth,[29] it has some limitations and does not consider vertical growth tendencies. In extreme cases it is likely that the genetic potential for attainable mandibular growth is significantly affected by the skeletal and muscular imbalance produced in these cases.

The stated limitations have also to be considered and overcome in future longitudinal studies.

The present study utilized a previously validated approach[24] that allowed analysis of disk status (length and displacement) as a continuous variable. This facilitates statistical analysis to identify the potential contribution of TMJ disk status to mandibular changes and avoids the potential error associated with subjective classification of partial disk displacement.[25] Assumptions for this TMJ disk status model and limitations of the application of Fishman maturation prediction method in the present methodological setting can be found elsewhere.[23,28]

Several cross-sectional studies have evaluated the association between TMJ disorders and mandibular dimensions. These studies reported that TMJ internal derangement was associated with reduced ramus height,[4,18–22] decreased mandibular body length,[4,21,22] mandibular[20–22] planes more convergent in the posterior region, and uprighting of the lower incisor relative to the mandibular plane.[21]

The present study did not show strong evidence suggesting that knowledge of TMJ disk status is a significant factor to be considered for orthodontic treatment planning. This is in agreement with several shortcomings in the available evidence regarding a relationship of occlusal factors with temporomandibular disorders (TMD) that preclude any strong conclusion regarding this relationship.[30,31] The contribution of muscle function, hormonal influences, environmental factors, and genetic potential must all be considered to provide a complete picture of the possible implications of disk displacement over mandibular growth. [30,31] Biomechanical and biochemical alterations may be more significant than disk position alone.

Conclusions

No evidence was found of TMJ disk abnormality or previous orthodontic treatments as significant contributors among adolescents to mandibular dimensional changes in growing individuals. However, the findings should be evaluated with caution due to the limitations identified in this study.

Contributors

Carlos Flores-Mir was responsible for the study conception and design, analysis and interpretation of the data. He participated in the drafting and critical revision of the paper. Leila Hamed participated in the data collection, drafting and critical revision of the paper. Brian Nebbe was responsible for the study conception and design, analysis and interpretation of the data. He participated in the drafting and critical revision of the paper. Giseon Heo participated in the interpretation of the data, drafting and critical revision of the paper. Paul W. Major was responsible for the study conception and design, analysis and interpretation of the data. He participated in the drafting and critical revision of the paper. Carlos Flores-Mir accepts full responsibility for the conduct of the study, had access to the data, and controlled the decision to publish. Carlos Flores-Mir is the guarantor.

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