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Degenerative temporomandibular joint changes associated with recent-onset disc displacement without reduction in adolescents and young adults

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ABSTRACT

This study evaluated the occurrence of degenerative temporomandibular joint (TMJ) changes in adolescents and young adults with recent on-set disc displacement without reduction (DDw/oR) using high-resolution cone beam computed tomography (CBCT). The associations between types of osteoarthrosis (OA) changes and clinical factors including disease duration were also examined. CBCT and clinical data of 300 patients (84.70% females, mean age 20.93 ± 4.77 years) diagnosed with unilateral DDw/oR (≤12 months) based on RDC/TMD were acquired. CBCT images of both symptomatic and contralateral asymptomatic TMJs were independently evaluated and scored by two radiologists. Associations between OA changes and gender, age, mouth opening and duration of DDw/oR were analyzed statistically. Condylar OA changes were present in 59.30% of the joints with DDw/oR. Early-stage OA changes (loss of continuity of articular cortex and/or surface destruction) constituted most (45.67%) of the alterations. Prevalence of early-stage OA increased from 24% to about 60% one month after TMJ closed-lock occurred. Logistic regression analysis showed the risk of developing early-stage OA changes was 5.33 times higher one month after onset of DDw/oR. A high prevalence of degenerative TMJ changes was observed with recent on-set DDw/oR in adolescents and young adults. Early diagnosis and intervention of DDw/oR is therefore prudent.

1. Introduction

Osteoarthrosis is a chronic disease, characterized by degeneration of the articular cartilage, subarticular bone loss, osteophyte formation, articular deformation and sclerosis of the temporomandibular joint (TMJ) (Toller, 1973; Ishibashi et al., 1995). It is a common manifestation of temporomandibular disorders (TMD) and is associated with TMJ condylar form and structural abnormalities. When TMJ degeneration is accompanied by arthralgia (joint pain), it is termed osteoarthritis (Dworkin and LeResche, 1992). Based on radiographic findings, the prevalence of osteoarthritic (OA) changes of the TMJ is estimated to vary from 8% to 16% in the general population, of which subarticular bone loss accounts for 11% (Toller, 1973; Mejersjö and Hollender, 1984). The prevalence might be as high as 35% if minimal flattening of the condyle is included (Brooks et al., 1992).

TMD signs and symptoms are usually more predominant in adults between 20 and 40 years old (Yap et al., 2003). Recent TMD studies, however, suggest an increasing prevalence of TMD in children and adolescents (Grosfeld et al., 1985; Motegi et al., 1992;

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Thilander et al., 2002; Köhler et al., 2009; Zhao et al., 2011; Lei et al., 2016). The frequency of TMJ osteoarthrosis/arthritis in adolescents has also risen drastically, and peaks at ages 15–19 years (Zhao et al., 2011). The TMJs of children and adolescents are in the process of growth and development. OA changes of the TMJ, if present, may interfere with normal condylar formation, leading to mandibular deviation, mandibular retrusion as well as anterior open bite (Krisjane et al., 2012).

The etiology of TMJ osteoarthrosis/arthritis is complicated and multifactorial in nature. Overloading and joint instability are universally deemed to be predisposing factors (Kalladka et al., 2014; Chisnoiu et al., 2015; Manfredini et al., 2016). Disc displacement, especially disc displacement without reduction (DDw/oR), has been associated with OA changes of the TMJ (Öğütcen-Toller et al., 2002; Takatsuka et al., 2005; Campos et al., 2008; Cortes et al., 2011; Dias et al., 2012; Gil et al., 2012; Melo et al., 2015). Displaced discs might interfere with condylar mobility and lead to increased loading of the anterior surfaces of condyles (Takatsuka et al., 2005). Articular cartilage and subarticular bone destruction gradually occur over time (Manfredini et al., 2016). Early diagnosis and intervention of TMJ osteoarthrosis/arthritis associated with DDw/oR is therefore prudent, especially in adolescents, as subarticular (subchondral) cortical bone formation only commences between the ages of 12 and 14 years (Lei et al., 2013).

This study evaluated the occurrence of degenerative TMJ changes in adolescents and young adults with recent-onset DDw/oR (less than 12 months) using high-resolution cone beam computed tomography (CBCT). The associations between types of condylar OA changes and clinical factors including disease duration were also examined.

2. Materials and methods

2.1. Patient population

Approval from the Biomedical Institutional Review Board of Peking University was obtained before starting the study (PKUSSIRB-201522045). Waiver of informed consent was granted, as this retrospective study involved no more than minimal risk to subjects, did not adversely affect the rights and welfare of subjects, contributed to greater public good, and could not practically be carried out otherwise. Subject inclusion criteria were as follows: (1) adolescents and young adults 10–30 years old; (2) diagnosed with unilateral DDw/oR based on the Research Diagnostic Criteria for TMD (RDC/TMD) (Dworkin and LeResche, 1992); and (3) recent-onset DDw/oR (less than 12 months). All subjects could vividly recall when they had experienced significant jaw lock or catch so that it would not open all the way (i.e. TMJ closed-lock accompanying acute DDw/oR). Subject exclusion criteria were: (1) prior TMD treatment (e.g. jaw exercises, splint therapy, arthrocentesis, arthroscopic surgery); (2) TMD signs/symptoms on the contralateral TMJ; and (3) Presence of systematic joint diseases (e.g. rheumatoid arthritis). Subjects with incomplete clinical information were also excluded. CBCT and clinical data of 300 patients who visited the Center for TMD & Orofacial Pain, Peking University School & Hospital of Stomatology from 2010 to 2014 were anonymized and enrolled. The age of subjects ranged from 11 to 30 years, with a mean age of 20.93 ± 4.77 years. Of the subjects, 84.7% were female while 15.3% were male. Clinical information including gender, age, history of TMJ clicking, history of TMJ closed-lock, maximum unassisted mouth opening, maximum assisted mouth opening, TMJ pain, and mouth opening pattern were collected. The latter six variables had been found to be expedient for distinguishing between different subtypes of disc displacements (Schmitter et al., 2008).

2.2. CBCT classifications of condylar OA changes

Bilateral CBCT images of the TMJs were obtained using a three-dimension multi-image micro-CT (J. Morita Corp., Kyoto, Japan) at 76–80 kV and 4.2–6.0 mA, field of view 4 × 4 cm or 6 × 6 cm. The scanned data were reconstructed, and multiple images of axial, coronal, and sagittal planes of the joints at 1.0-mm slice intervals were acquired.

CBCT images of condylar OA changes were classified into six categories: Type I, loss of continuity of the articular cortex; Type II, surface erosion or destruction; Type III, deviation in form; Type IV, sclerosis; Type V, osteophyte; and Type VI, cyst-like lesion (Fu et al., 2007; Koyama et al., 2007; Alexiou et al., 2009). Types I and II were considered early-stage OA changes, whereas Types III to VI were deemed late-stage OA changes (Toller, 1973; Wiberg and Wanman, 1998; Fu et al., 2007; Koyama et al., 2007; Zhao et al., 2011). Bilateral TMJ CBCT images were evaluated in consecutive slices, and all condylar OA changes were reported by two experienced radiologists who were blinded to the clinical diagnoses and information. The assignment of multiple categories was permissible for individual joints, e.g., Types I and II or Types I and IV, for a single TMJ. Consensus was achieved through discussion/consultation with a third, senior radiologist when there were disagreements. To determine associations between types of condylar OA changes and clinical factors including disease duration (i.e. time from first onset of DDw/oR), subjects were categorized into three groups. Group A comprised subjects without OA changes. Group B encompassed subjects with only early-stage OA changes (Types I and/or II) in the symptomatic TMJ. Group C included subjects exhibiting late-stage OA changes (Types III to IV) together with Type I or II OA alterations.

2.3. Statistical analysis

A Chi-square test was used to compare the proportions of condylar OA changes as well as the gender distribution. Clinical data was explored for normality using quantile–quantile plot (Q–Q plot) and analyzed with an independent-samples *t*-test (for parametric variables, i.e. age, maximum unassisted mouth opening) or a Mann–Whitney *U*-test (for nonparametric variables, i.e. disease duration) to compare differences in clinical factors between Groups A and Groups B/C. Stepwise logistic regression analysis was used to determine whether early-stage OA changes were independently associated with gender, age, maximum unassisted mouth opening, and disease duration of DDw/oR. All data analyses were performed using SPSS software version 21.0 at a significance level of $P < 0.05$.

3. Results

3.1. Descriptive data

Maximum unassisted mouth opening ranged from 19 mm to 52 mm (mean of 32.34 ± 6.90 mm). Duration from first onset of DDw/oR ranged from 0.03 months to 12 months (mean of 3.47 ± 3.68 months). The onset of TMJ closed-lock was less than 6 months for the majority of subjects (86.30%). Among these patients, onset was less than 3 months for 63.30%. In all, 59.30% (178/300) of the symptomatic TMJs with DDw/oR presented with OA changes (Types I to VI), whereas 40.70% (122/300) were radiographically normal. There was no significant difference in sex distribution between subjects without and those with TMJ OA changes (Types I to VI). Early-stage OA (Types I and/or II) constituted 76.97% of the 178 symptomatic TMJs, whereas late-stage OA (Types III to VI) accounted for 23.03%. For the asymptomatic contralateral TMJs, 35.00% (105/300) showed condylar OA changes, and the rest (65.00%, 195/300) were radiographically normal.

3.2. Percentages of condylar OA changes

The percentage of the various condylar OA changes in the symptomatic and contralateral asymptomatic TMJs are shown in Table 1. Early OA changes (Type I [Fig. 1] and/or Type II [Fig. 2]) were observed in 45.67% of the symptomatic TMJs and were significantly more prevalent than in the contralateral asymptomatic TMJs (15.33%). Late-stage OA changes (especially Type III [deviation in form] and IV [sclerosis]) were observed in 13.63% of the symptomatic TMJs. This prevalence was, however, significantly lower than in the contralateral asymptomatic TMJs (19.67%). Type V (osteophyte) and type VI (cyst-like lesion) were both rarely observed.

3.3. Comparison of clinical factors

No significant difference in gender and age distribution was observed between Group A and Groups B/C. When compared to Group A, the maximum unassisted mouth opening was significantly greater in Group B and smaller in Group C, respectively. Disease duration was significantly longer in Groups B and C when compared to Group A (Table 2).

The percentage of early-stage OA changes increased rapidly and considerably from 24.20% for disease duration $t \leq 1$ m (month) to 60.60%, 63.80% and 56.10% when disease duration was $1\ m < t \leq 3\ m$, $3\ m < t \leq 6\ m$ and $6\ m < t \leq 12\ m$, respectively. No significant differences in prevalence of early-stage OA changes were observed among the latter three groups (Table 3). The percentage of late-stage OA did not appear to be influenced by disease duration (Table 3).

3.4. Correlation between gender/age/maximum unassisted mouth opening/disease duration and early/late-stage OA

Stepwise logistic regression analysis demonstrated that the disease duration was significantly and positively related to early-stage OA as well as late-stage OA. The maximum unassisted mouth opening was positively associated with early-stage OA and negatively related to late-stage OA. The P values were still significant even after controlling for other variables ($P < 0.01$). When disease duration was further condensed into two groups, $t \leq 1$ m (T1) and $1 < t \leq 12$ m (T2), stepwise logistic regression analysis showed that the possibility of early-stage OA increased to 5.33 times at T2 when compared to T1 ($P < 0.001$). There was, however, no such disease duration dependency in the percentage of late-stage OA (Table 4).

4. Discussion

The frequency and type of degenerative TMJ changes in adolescents and young adults with recent-onset DDw/oR was investigated and related to different clinical factors. The transition from normal TMJ structure to DDwR (disc displacement with reduction) to DDw/oR to degenerative joint disease is still unclear. Although some authors state that DDwR may well evolve to DDw/oR (Huddleson Slater et al., 2004; Chantaracherd et al., 2015), cohort studies have found otherwise. Longitudinal data in adolescents (Magnusson et al., 2000) and patients (Greene and Laskin, 1988; Manfredini et al., 2013) suggest that DDwR seldom develops into DDw/oR. The interaction between DDw/oR and the development of degenerative TMJ changes is likewise uncertain.

In the present study, 59.30% of subjects with recent-onset DDw/oR presented with condylar OA changes. Most of the OA changes were Type I and/or II in nature. Recent-onset DDw/oR (within 1 year) was consequently associated with early-stage condylar OA. Previous studies had also demonstrated the link between DDw/oR and TMJ osteoarthrosis/osteoarthritis (Öğütcen-Toller et al., 2002; Takatsuka et al., 2005; Campos et al., 2008; Cortes et al., 2011; Dias et al., 2012; Gil et al., 2012; Melo et al., 2015). Unlike these studies in which only the coexistence of DDw/oR and TMJ OA changes were reported, the present study also explored the influence of DDw/oR onset on TMJ OA changes.

The percentage of early-stage OA increased considerably from 24% when onset was within 1 month to approximately 60% after 1–12 months. The risk of developing early-stage OA changes was in fact 5.33 times higher 1 month after the onset of TMJ closed-lock. Bertram et al. and Emshoff et al. reported that imaging parameters of DDw/oR and osteoarthrosis appear to be important determinants of horizontal mandibular and vertical ramus deficiencies as well as mandibular backward positioning and clockwise rotation (Bertram et al., 2011; Emshoff et al., 2011). DDw/oR and osteoarthrosis can thus interfere with facial morphology and occlusion (Krisjane et al., 2012; Sakar et al., 2013; Xie et al., 2015; Manfredini et al., 2016). Interventions for DDw/oR should therefore be instituted early upon TMJ closed-lock onset to curtail possible degenerative condylar changes, especially in children and adolescents. The prevalence of TMJ osteoarthrosis/osteoarthritis has been found to increase with advancing age in the latter groups (Grosfeld et al., 1985; Motegi et al., 1992; Thilander et al., 2002; Köhler et al., 2009; Zhao et al., 2011; Lei et al., 2016).

In a recent magnetic resonance imaging (MRI) study, Grossmann et al. (2016) reported a statistically significant relationship between osteophyte formation and DDw/oR in adults (Grossmann et al., 2016). Osteophytes were invariably located in the anterior surface of the condyle, suggesting a possible cause-and-effect relationship between DDw/oR and osteoarthrosis/osteoarthritis. Little osteophyte formation was anticipated in the present study, however, as TMJ OA changes rarely coexist with DDwR (Moncada et al., 2014; Melo et al., 2015) and as the onset of DDw/oR was less than 6 months for 90% of the subjects. The presence of mainly early-stage OA in the present study of adolescents and young adults lends further support to the causality between DDw/oR and TMJ OA (Toller, 1973). Results were consistent with those of Moncada et al., who found a significant association between DDw/oR and degenerative bone changes in children and adolescents with TMD by using MRI (Moncada et al., 2014).

TMJ osteoarthrosis/osteoarthritis (OA) associated with recent-onset DDw/oR was not biased by age and gender in the present study (Table 4). OA is age-related, and generally occurs after the fourth decade of life in the weight-bearing joints, for example, knee OA (Deshpande et al., 2016). TMD OA is also found to be age-related (Pereira et al., 1994; Widmalm et al., 1994; Ishibashi et al., 1995; Alexiou et al., 2009). However, unlike the weight-bearing joints, TMD is common in the population aged 20–40 years (Yap et al., 2003), and TMD OA in adolescents and young adults has also risen drastically (Zhao et al., 2011), which might be attributed more

Table 1
Percentages of condylar OA radiological signs in bilateral sides of TMJ.

		Symptomatic joints (n = 300)	Total	Contralateral joints (n = 300)	Total
Early-stage OA	Type I	40.0%	45.67%	16.0%[a]	15.33%[a]
	Type II	25.0%		6.0%[a]	
Late-stage OA	Type III	5.7%	13.63%	11.3%[a]	19.67%[a]
	Type IV	7.7%		11.3%	
	Type V	1.0%		0.7%	
	Type VI	0.0%		1.0%	

Type I, loss of continuity of articular cortex; Type II, surface erosion or destruction; Type III, deviation in form; Type IV, sclerosis; Type V, osteophyte; Type VI, cyst-like lesion.
[a] Chi-square test $P < 0.05$.

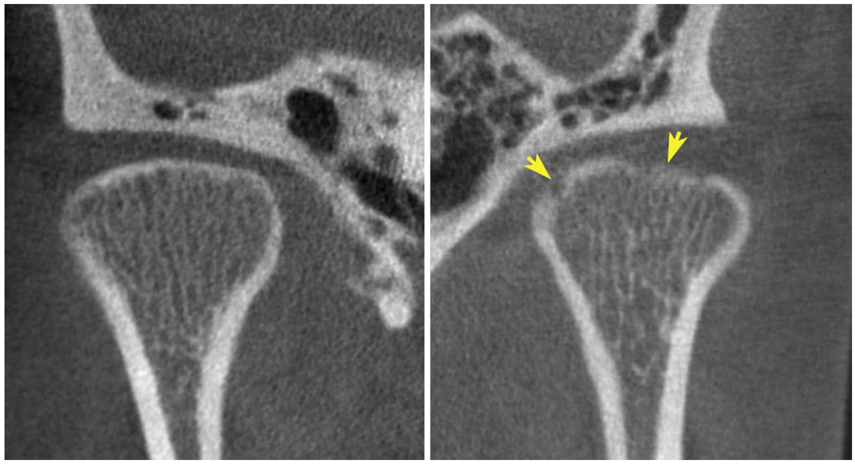

Fig. 1. Female patient, 20 years old, who presented with complaints of limited and deviated mandibular opening to the left for 1 week. She had had a history of clicking and occasional joint catch on the left joint in the morning for 3 weeks. Diagnosis: DDw/oR on the left joint. Note the discontinuity of the articular cortex (arrow head) on the left condyle.

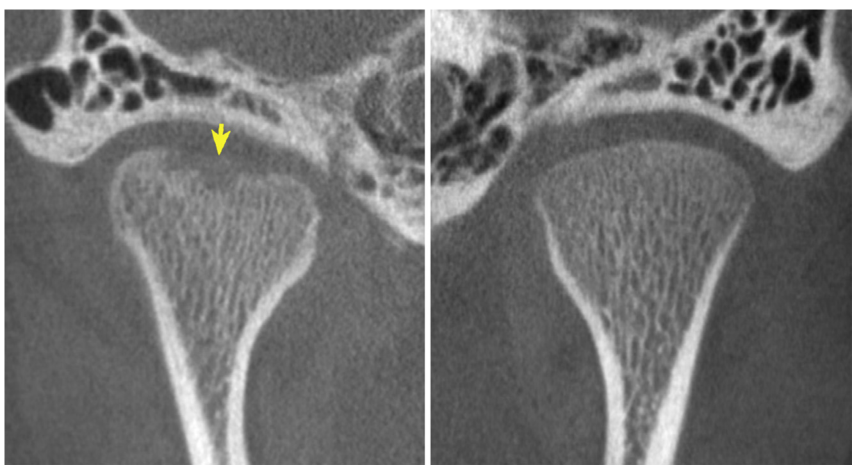

Fig. 2. Male patient, 14 years old, who presented with complaints of limited mouth opening for 3 months. He had had a history of clicking and occasional joint catch on the right joint for 7 month. Diagnosis: DDw/oR on the right joint. Note the surface destruction involved the articular cortex and cancellous bone (arrow head) on the right condyle.

to pathological factors such as the overloading and joint immobility caused by DDw/oR, rather than age itself, especially in a young population. The difference in findings may be attributed to the age limit (less than 30 years) of our study. It is plausible that OA changes in the present study are due to direct osseous alterations related to pathosis (i.e. DDw/oR) rather than to age-related transformations.

No association was also observed between sex and degenerative TMJ changes in other imaging studies (Lamot et al., 2013; Grossmann et al., 2016). One explanation might be the age limit in our study, and the other might be that the hormonal (estrogen) effect alone does not play a significant role in the initiation of TMD (Weiler et al., 2013).

The high detection rate of condylar OA changes associated with recent-onset DDw/oR can be accredited to the enhanced diagnostic

Table 2
Comparison of gender/age/maximum unassisted mouth opening/duration from first onset of DDw/oR between patients with/without OA.

	Group A (n = 122)	Group B (n = 137)	Group C (n = 41)
Gender			
Female	83.60%	82.50%	95.10%
Male	16.40%	17.50%	4.90%
Age (years)	20.90 ± 5.01	20.44 ± 4.48	22.66 ± 4.69
Mouth opening (mm)	31.25 ± 6.78	34.36 ± 6.72[a]	28.85 ± 5.79[a]
Disease duration (months)	2.27 ± 3.31	4.41 ± 3.67[b]	3.83 ± 3.80[b]

Group A: patients without OA; Group B: patients with early-stage OA; Group C: patients with late-stage OA.
[a] Independent-samples *t*-test P < 0.05, Group B/Group C compared to Group A, respectively.
[b] Mann–Whitney *U*-test P < 0.05, Group B/Group C compared to Group A, respectively.

Table 3
Percentages of the early/late-stage OA in different disease-duration stages.

	$t \le 1$ m	1 m $< t \le 3$ m	3 m $< t \le 6$ m	6 m $< t \le 12$ m
Group A (n)	77	20	14	11
Group B (n)	30	40	44	23
	24.20%	60.60%[a]	63.80%[a]	56.10%[a]
Group C (n)	17	6	11	7
	13.70%	9.10%	15.90%	17.10%
Total OA percentage	37.90%	69.70%[a]	79.70%[a]	73.20%[a]

m, month; Group A: patients without OA; Group B: patients with early-stage OA; Group C: patients with late-stage OA.
[a] Chi-square test P < 0.05, compared to patients with disease duration $t \le 1$ month.

Table 4
Variables and clinical factors related to early-stage OA/late-stage OA.

	Group A (n = 122)	Group B (n = 137)	ORs-b (95% CI)	P	Group C (n = 41)	ORs-c (95% CI)	P
Gender							
Female (%)	83.60	82.50	0.95 (0.47, 1.94)	0.89	95.10	2.32 (0.49, 10.86)	0.29
Male (%)	16.40	17.50			4.90		
Age (years)	20.90 ± 5.01	20.44 ± 4.48	0.97 (0.92, 1.03)	0.30	22.66 ± 4.49	1.04 (0.96, 1.12)	0.38
Mouth opening (mm)	31.25 ± 6.78	34.36 ± 6.72	1.05 (1.01, 1.11)	0.01	28.85 ± 5.79	0.90 (0.84, 0.96)	0.00
Disease duration (months)	2.27 ± 3.31	4.41 ± 3.67	1.18 (1.08, 1.28)	0.00	3.83 ± 3.80	1.22 (1.09, 1.37)	0.00
T1 (%)	63.11	21.90	1	0.00	41.50	1	0.20
T2 (%)	36.89	78.10	5.33 (3.04, 9.35)		58.50	2.02 (0.69, 5.94)	

Group A: patients without OA; Group B: patients with early-stage OA; Group C: patients with late-stage OA.
OR-b, odds ratio (Group B compared to Group A); OR-c, odds ratio (Group C compared to Group A); T1, disease duration ≤1 month; T2, 1 month < disease duration ≤ 12 months.

ability of the high-resolution CBCT used in our study. It has been shown to provide superior reliability and greater accuracy than two-dimension radiographs (Honda et al., 2006; Fu et al., 2007; Honey et al., 2007). Moreover, OA changes were observed in 35% of the contralateral asymptomatic joints. TMJ osteoarthrosis is frequently observed in the general population. Widmalm et al. stated that 4% of persons under 40 years old, and 22% of those over 40 years old, showed signs of TMJ arthrosis (Widmalm et al., 1994). These degenerative TMJ changes may not be related to disc displacements and could stem from micro-trauma, ligament laxity, as well as parafunctions (Kalladka et al., 2014). This also explains in part the presence of late-stage OA changes in both symptomatic and contralateral asymptomatic joints (Table 1). Furthermore, disc displacements are frequently encountered in bilateral joints (Milano et al., 2000).

5. Conclusion

An association between the onset of DDw/oR and degenerative TMJ changes was found in this study. The risk of developing early-stage OA changes increased appreciably 1 month after the onset of DDw/oR. Early diagnosis and intervention of DDw/oR is therefore recommended, especially in children and adolescents, to minimize possible dento-maxillofacial consequences.

Conflict of interest

The authors declare that there is no conflict of interest in regard to this work.

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