Dentofacial features of Class II malocclusion associated with maxillary skeletal protrusion: A longitudinal study at the circumpubertal growth period

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Introduction: The purpose of this study was to describe the craniofacial growth changes of subjects with Class II malocclusion associated with maxillary skeletal protrusion at the circumpubertal growth period. **Methods:** The records of 25 untreated subjects with normal Class I occlusion and 25 untreated Class II subjects (14 boys and 11 girls in each group) were selected from the longitudinal records of the University of Michigan Growth Study. All Class II subjects had maxillary protrusion. Measurements were made on lateral and posteroanterior cephalograms and on dental casts at 2 times. The first observation (T1) was during the prepubertal growth phase (vertebral stages CS1 to CS3). The second observation (T2) was during the postpubertal phase of growth (vertebral stages CS4 to CS6). The following comparisons were made: Class I vs Class II at T1, Class I vs Class II at T2, and growth changes in Class I vs Class II. **Results:** No dentofacial feature studied showed any statistically significant difference when comparing the growth changes between the Class II and the Class I groups. **Conclusions:** These results suggest that dentofacial features of Class II malocclusion associated with maxillary skeletal protrusion are maintained during the circumpubertal period, and that growth changes in this type of Class II disharmony are similar to those in subjects with normal occlusion. (Am J Orthod Dentofacial Orthop 2009;135:568.e1-568.e7)

Occlusal changes in growing subjects with Class II malocclusion have been investigated extensively. Moyers and Wainright[1] stated that a distal step in the deciduous dentition most likely reflects an underlying skeletal imbalance and typically results in a Class II malocclusion in the permanent dentition. Likewise, Arya et al[2] observed that all subjects with a distal-step relationship of the deciduous second molars ultimately had a Class II relationship of the permanent molars. Bishara et al[3] concluded that Class II malocclusion, when diagnosed on the basis of the occlusal features, never is "self-correcting" in growing patients.

Investigations of growing subjects considering other diagnostic features beside occlusal characteristics, however, are few, and the literature lacks investigations on specific growth changes in Class II subjects with maxillary protrusion. Baccetti et al[4] studied growth changes in children with Class II malocclusion from the deciduous through the mixed dentitions using lateral cephalograms and dental casts. They found that the clinical signs of Class II malocclusion (both at the sagittal and the transverse levels) are evident in the deciduous dentition and persist into the mixed dentition. Bishara et al[5] noted that the growth profiles of the various dentofacial structures in Class II subjects with increased ANB angle were essentially similar to those of normal subjects. On the other hand, Kerr and Hirst[6] and Ngan et al[7] pointed out reduced mandibular growth rates in subjects with untreated Class II malocclusion compared with normal controls from 5 to 15 years and 7 to 14 years of age, respectively. These data were confirmed in a recent study by Stahl et al[8] on the growth features of Class II subjects with mandibular deficiency studied throughout the circumpubertal period. With regard to the transverse characteristics in Class II malocclusion, a previous study on

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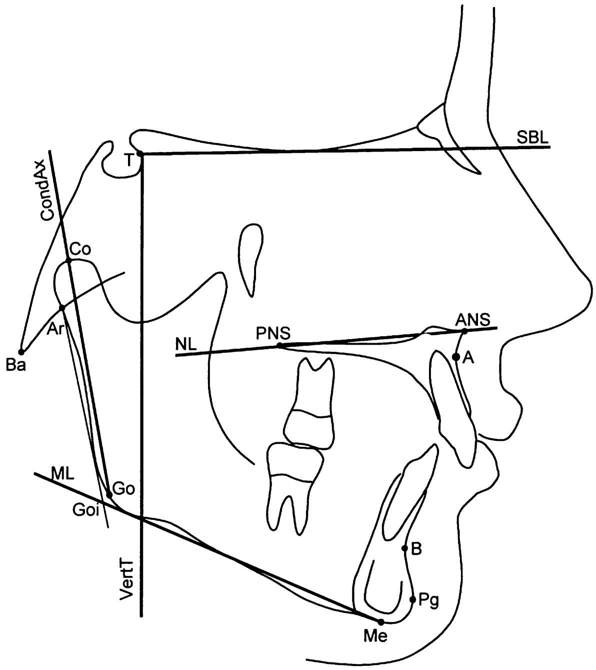

Fig 1. Cephalometric analysis on lateral films: skeletal landmarks and measurements.

Class II subjects mainly with mandibular retrusion found transverse dentoskeletal deficiency of the maxilla when compared with normal subjects.[9]

The characteristics of Class II growing subjects from the mixed through the permanent dentition in the 3 planes of space have not been studied in detail. In addition, little is known about growth in Class II patients with maxillary skeletal protrusion. Our aim in this study, therefore, was to investigate the growth characteristics of subjects with Class II malocclusion associated with maxillary protrusion compared with normal subjects during the circumpubertal period. The main features of this study were the use of a biologic indicator of skeletal maturity during the pubertal ages (the cervical vertebral maturation [CVM] method),[10] and the analysis of dentofacial modifications by evaluation of lateral cephalograms, posteroanterior (PA) cephalograms, and dental casts taken at the same time in our subjects.

MATERIAL AND METHODS

The longitudinal records of the University of Michigan Growth Study were searched for untreated subjects with Class II Division 1 malocclusion; a total of 168 Class II subjects were identified.[11] In these subjects, the sagittal position of the maxilla was analyzed on lateral cephalograms at a prepubertal stage (assessed on the basis of the stages of the CVM method).[9] The SNA angle and the distance from Point A to nasion perpendicular were the variables selected for the analysis. Class II subjects with maxillary skeletal protrusion were diagnosed according to the indications by McNamara[12]: when the SNA angle was larger than 84° and the distance from Point A to nasion perpendicular was greater than 4 mm. Twenty-five Class II subjects matched the selection criterion. In addition, 25 Class I untreated subjects were selected from the University of Michigan Growth Study as the control group. Both groups comprised 14 boys and 11 girls.

Observations were made at 2 time periods. The first observation (T1) was during the prepubertal growth phase (vertebral stages CS1 to CS3). The second observation (T2) was an average of 3 years after T1, during the postpubertal growth phase (vertebral stages CS4 to CS6). At each observation, lateral cephalograms, PA cephalograms, and dental casts were available for each subject in both groups.

The following measurements on casts were registered with a 0.01-mm precision dial caliper: (1) intermolar widths (maxillary, the distance between the central fossae of the maxillary right and left first permanent molars; mandibular, the distance between the tips of the mesiobuccal cusps of the mandibular right and left first permanent molars); (2) intercanine width, the distance between the tips of the cusps of the canines; and (3) overjet, the distance from the labial surface of the mandibular central incisors to the incisal edge of the maxillary central incisors.

The cephalometric analysis on lateral cephalograms was based on a reference system with lines traced through stable craniofacial structures, as described previously for longitudinal cephalometric studies on growing subjects.[4]

1. Stable basicranial line (SBL), a line traced through Point T that is tangent to the lamina cribosa of the ethmoid. Point T, the most superior point of the anterior wall of sella turcica at the junction with tuberculum sellae.
2. Vertical T (VertT), a line perpendicular to SBL and passing through Point T.

A cephalometric analysis based on this reference system was constructed by using the planes and landmarks shown in Figure 1. The definitions of these planes and landmarks were described previously.[4]

The following linear measurements of sagittal relationships were considered: Point A (A)-VertT, Point B (B)-VertT, and gonial intersection (Goi)-VertT.

The following linear measurements of mandibular dimensions were considered: condylion-pogonion (Co-Pg), Co-Goi, and Goi-Pg.

The following angular measurements of cranial base angulations were considered: basion (Ba)-T-VertT and articulare (Ar)-T-VerT.

The following angular measurements of vertical relationships were considered: mandibular line (ML)-SBL, nasal line (NL)-SBL, and ML-NL.

The following angular measurements of mandibular ramus and condyle inclinations were considered: gonial angle (Ar-Goi-Me), condylar axis (CondAx)-SBL, and CondAx-ML.

The cephalometric analysis on posteroanterior cephalograms described by Cameron et al[13] was used. The following bilateral cephalometric landmarks and corresponding definitions were used.

1. Euryon (Eu), the most lateral point of the cranial vault.
2. Medio-orbitale (Mo), the most medial point of the orbital orifice.
3. Latero-orbitale (Lo), the intersection of the lateral wall of the orbit and the greater wing of the sphenoid (the oblique line).
4. Zygoma (Zyg), the most lateral point of the zygomatic arch.
5. Zygomandibulare (Zmd), the intersection between the lower margin of the zygomatic bone and the lateral contour of the mandibular ramus.
6. Condylar lateral (Cdl), the point located at the lateral pole of the condylar head.
7. Maxillomandibulare (Mmd), the intersection between the lower margin of the maxilla and the medial contour of the mandibular ramus.
8. Maxillare (Mx), the point located at the depth of the concavity of the right lateral maxillary contour, at the junction of the maxilla and the zygomatic buttress.
9. Latero-nasal (Ln), the most lateral point of the nasal cavity.
10. Gonion (Go), the point located at the right gonial angle of the mandible.
11. Antegonion (Ag), the point located at the right antegonial notch.

From the digitized PA cephalograms, 11 skeletal width measurements were derived for each patient at each observation time by connecting the bilateral cephalometric landmarks (Fig 2).

A total of 20 repeated measurements were made on 10 subjects randomly selected to calculate method errors for all variables. All films were retraced and redigitized, and cephalometric variables were recalculated. The measurements were also repeated on the dental casts. The error of the method was determined by using intraclass correlation coefficients.

Intraclass correlation coefficients were calculated to compare within-subjects variability with between-subjects variability. Correlation coefficients for the cephalometric measurements were extremely high; with the exception of 2 variables (CondAx-ML and ML-SBL), all correlation coefficients were greater than 0.95. These exceptions might be explained by slight variability in the construction of the mandibular plane.

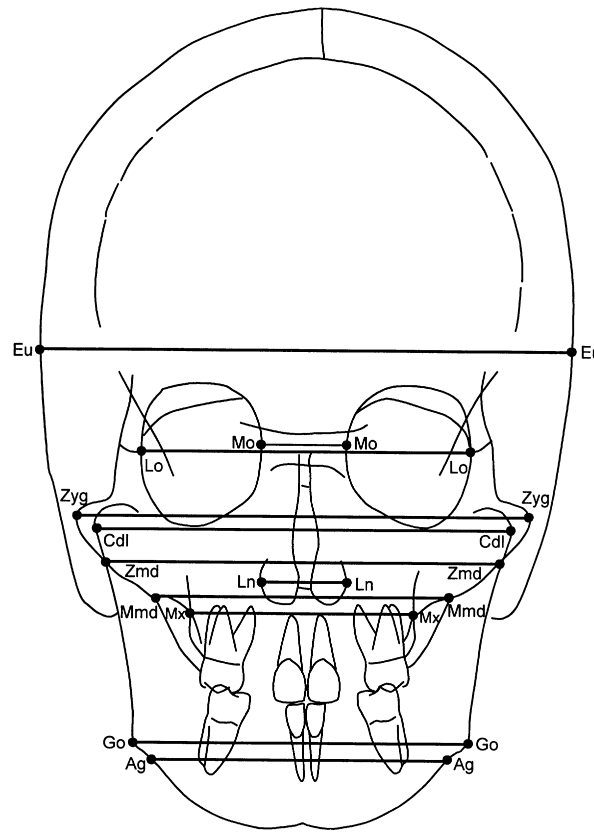

Fig 2. Cephalometric analysis on PA films: skeletal landmarks and measurements.

Statistical analysis

Parametric statistics were used after determination of the normality of distribution for the variables examined with the Shapiro-Wilks test. The Student *t* test for independent samples was used to compare starting forms between Class II and Class I samples at T1, final forms at T2, and growth changes from T1 to T2. Significance was determined with a statistical package (version 12.0, SPSS for Windows, SPSS, Chicago, Ill) at the levels of $P < 0.05$ and $P < 0.01$.

RESULTS

The results of the comparisons between the Class I and Class II groups on the measurements at T1 are reported in Table I along with descriptive statistics. The Class II subjects at T1 showed significantly increased

Table I. Descriptive statistics and statistical comparison of measurements between Class II subjects with maxillary protrusion and Class I subjects at T1

	Class II (n = 25)		Class I (n = 25)			
Measurement	*Mean*	*SD*	*Mean*	*SD*	P	*Significance*
On casts (mm)						
Maxillary intermolar width	44.9	2.6	45.5	2.2	0.425	NS
Mandibular intermolar width	46.1	2.7	46.3	1.9	0.743	NS
Maxillary intercanine width	31.6	2.1	31.2	2.0	0.569	NS
Mandibular intercanine width	25.4	1.9	25.6	2.3	0.764	NS
Overjet	5.9	2.4	3.6	1.5	0.001	*
On lateral cephalograms						
A-VertT (mm)	70.0	4.5	67.2	4.0	0.007	*
B-VertT (mm)	61.9	5.7	61.2	6.1	0.660	NS
Goi-VertT (mm)	8.4	5.0	10.3	5.5	0.251	NS
Co-Pg (mm)	112.6	3.9	113.5	4.3	0.385	NS
Co-Goi (mm)	56.4	3.0	57.1	3.8	0.356	NS
Goi-Pg (mm)	74.6	2.7	75.6	3.2	0.457	NS
Ba-T-VertT (°)	34.4	5.1	35.1	5.2	0.666	NS
Ar-T-VertT (°)	28.6	5.1	29.7	4.6	0.439	NS
ML-SBL (°)	23.8	4.4	25.0	4.8	0.256	NS
NL-SBL (°)	−2.0	3.1	−1.9	4.0	0.914	NS
NL-ML (°)	25.8	4.3	26.8	4.5	0.451	NS
Ar-Goi-Me (°)	126.7	4.9	126.4	5.2	0.875	NS
CondAx-SBL (°)	79.9	4.8	81.4	4.9	0.321	NS
CondAx-ML (°)	125.6	6.9	123.8	5.3	0.332	NS
On PA cephalograms (mm)						
Eu	154.4	5.9	153.1	3.4	0.353	NS
Lo	91.3	4.8	90.6	3.5	0.617	NS
Mo	23.0	2.8	22.1	1.9	0.238	NS
Zyg	123.2	5.9	123.8	3.9	0.664	NS
Cdl	111.1	5.9	111.7	4.7	0.704	NS
Zmd	107.7	5.7	107.6	5.1	0.966	NS
Ln	26.6	2.1	26.9	2.4	0.680	NS
Mdm	78.1	4.3	78.0	4.2	0.912	NS
Mx	62.6	4.1	62.5	3.2	0.941	NS
Go	91.5	4.6	93.2	5.1	0.136	NS
Ag	81.8	4.1	82.9	4.1	0.350	NS

NS, Not significant.
$*P < 0.01$.

overjet and maxillary protrusion (A-VertT) when compared with the normal subjects. No other significant differences where found at T1 between the 2 groups.

At T2, the Class II subjects still had a significant excess in overjet and significant maxillary protrusion (Table II). No significant differences between Class II and Class I subjects were found for the growth interval, T1 to T2 (Table III).

DISCUSSION

We evaluated for the first time the longitudinal growth changes in dentoskeletal structures of subjects with untreated Class II malocclusion characterized by maxillary skeletal protrusion. A specific feature of this study was the use of the CVM method to analyze modifications during the circumpubertal ages.

Only 25 of the 168 subjects with Class II Division 1 malocclusion from the University of Michigan Growth Study had the cephalometric features of maxillary protrusion at T1.[11] The low prevalence rate for maxillary protrusion in Class II malocclusion (14.8%) confirms previous observations by McNamara[12] in subjects in the early mixed dentition (13.8%). From an epidemiologic point of view, this type of skeletal disharmony therefore appears to be significantly less prevalent than the association between Class II occlusal signs and mandibular retrusion (about 60% of Class II subjects).[12]

Different cephalometric measures to diagnose maxillary or mandibular position in the sagittal plane can lead to different outcomes. For instance, Rosenblum[14] indicated that the angle N-A to Frankfort horizontal is

Table II. Descriptive statistics and statistical comparison of measurements between Class II subjects with maxillary protrusion and Class I subjects at T2

	Class II (n = 25)		*Class I (n = 25)*			
Measurement	*Mean*	*SD*	*Mean*	*SD*	P	*Significance*
On casts (mm)						
Maxillary intermolar width	45.5	2.5	46.4	2.2	0.293	NS
Mandibular intermolar width	46.7	2.7	46.7	2.2	0.996	NS
Maxillary intercanine width	33.4	2.1	33.8	2.4	0.464	NS
Mandibular intercanine width	25.4	1.7	25.2	1.6	0.563	NS
Overjet	5.3	2.2	3.4	1.6	0.001	†
On lateral cephalograms						
A-VertT (mm)	72.1	4.5	69.6	4.5	0.021	*
B-VertT (mm)	64.8	6.8	64.8	6.5	0.970	NS
Goi-VertT (mm)	9.7	6.1	10.3	6.6	0.721	NS
Co-Pg (mm)	121.1	5.1	121.1	6.2	0.976	NS
Co-Goi (mm)	61.6	3.3	61.2	3.7	0.699	NS
Goi-Pg (mm)	80.0	3.2	81.1	4.3	0.322	NS
Ba-T-VertT (°)	34.4	4.7	35.1	5.2	0.661	NS
Ar-T-VertT (°)	28.8	5.6	29.6	4.9	0.585	NS
ML-SBL (°)	23.4	5.4	23.6	5.3	0.881	NS
NL-SBL (°)	−1.8	3.3	−1.6	4.5	0.920	NS
NL-ML (°)	25.0	5.0	25.1	4.3	0.956	NS
Ar-Goi-Me (°)	125.5	5.0	125.7	5.2	0.875	NS
CondAx-SBL (°)	80.2	5.0	81.0	6.5	0.556	NS
CondAx-ML (°)	125.1	7.5	123.8	5.5	0.494	NS
On PA cephalograms (mm)						
Eu	156.0	6.1	154.8	3.4	0.379	NS
Lo	93.4	4.8	93.0	3.5	0.735	NS
Mo	24.3	3.3	23.2	2.5	0.261	NS
Zyg	128.7	6.1	128.8	4.1	0.939	NS
Cdl	116.9	5.8	116.2	5.4	0.634	NS
Zmd	113.6	6.3	112.1	5.5	0.332	NS
Ln	28.7	2.4	28.6	2.4	0.864	NS
Mmd	82.3	4.5	81.5	4.2	0.501	NS
Mx	65.1	4.5	64.3	2.9	0.427	NS
Go	96.2	5.3	98.0	6.0	0.176	NS
Ag	85.7	4.9	86.2	4.7	0.664	NS

NS, Not significant.
$^{*}P < 0.05$; $^{\dagger}P < 0.01$.

highly reliable for the position of the maxilla, and, when using this angle to classify maxillary position, a greater prevalence rate of maxillary protrusion is found in Class II patients with respect measurements that involve the S-N plane. The method of identification of sagittal skeletal relationships used in this study included both measurements that comprised the S-N plane and those constructed by using the Frankfort horizontal plane. This cephalometric protocol, therefore, was intended to overcome possible limitations due to the exclusive use of either measure of maxillary/mandibular positions in the sagittal dimension.

Our findings showed that no significant transverse deficiency is associated with Class II malocclusion when it is characterized by maxillary skeletal protrusion. On the contrary, a previous study reported a significant transverse discrepancy between the maxillary and mandibular arches in subjects with Class II malocclusion when associated mainly with mandibular skeletal retrusion.[9] The transverse discrepancy in these subjects could be ascribed to deficiency in the transverse dimension of the maxilla at both the skeletal and dental levels. The same tendency was described in Class II subjects observed from the deciduous through the mixed dentitions.[4] Once again, mandibular skeletal retrusion was a main feature of that Class II sample.

When the longitudinal growth changes in Class II malocclusion associated with maxillary protrusion were analyzed, the lack of a tendency to self-correction of the dentofacial features of the malocclusion became apparent. The differences in growth modifications between Class II and Class I subjects from T1 to T2

Table III. Descriptive statistics and statistical comparison of growth changes between Class II subjects with maxillary protrusion and Class I subjects

	Class II (n = 25)		Class I (n = 25)			
Measurement	*Mean*	*SD*	*Mean*	*SD*	P	*Significance*
On casts (mm)						
Maxillary intermolar width	0.6	1.6	0.9	0.9	0.511	NS
Mandibular intermolar width	0.7	1.1	0.4	1.2	0.351	NS
Maxillary intercanine width	1.8	1.8	2.6	2.2	0.205	NS
Mandibular intercanine width	0.02	2.0	−0.4	2.4	0.447	NS
Overjet	−0.6	2.1	−0.2	1.0	0.445	NS
On lateral cephalograms						
A-VertT (mm)	2.1	3.4	2.4	1.4	0.645	NS
B-VertT (mm)	2.9	2.9	3.7	2.0	0.306	NS
Goi-VertT (mm)	1.2	3.1	0.0	2.3	0.114	NS
Co-Pg (mm)	8.6	3.0	7.5	3.6	0.225	NS
Co-Goi (mm)	5.1	2.4	5.1	2.1	0.902	NS
Goi-Pg (mm)	5.4	2.0	4.4	1.9	0.100	NS
Ba-T-VertT (°)	0.0	2.3	0.1	1.7	0.952	NS
Ar-T-VertT (°)	0.2	2.6	0.0	2.0	0.728	NS
ML-SBL (°)	−0.4	2.1	−1.4	1.6	0.082	NS
NL-SBL (°)	0.3	1.5	0.3	2.5	1.00	NS
NL-ML (°)	−0.8	1.9	−1.7	2.2	0.080	NS
Ar-Goi-Me (°)	−1.2	2.6	−0.7	2.2	0.508	NS
CondAx-SBL (°)	0.3	3.2	−0.3	4.5	0.530	NS
CondAx-ML (°)	−0.5	2.8	0.0	2.1	0.480	NS
On PA cephalograms (mm)						
Eu	1.6	1.1	1.7	1.5	0.878	NS
Lo	2.1	1.3	2.3	1.1	0.462	NS
Mo	1.3	1.3	1.2	1.6	0.671	NS
Zyg	5.4	2.4	5.0	3.0	0.566	NS
Cdl	5.8	2.6	4.5	3.0	0.125	NS
Zmd	5.9	3.3	4.5	3.2	0.181	NS
Ln	2.1	0.9	1.7	1.0	0.110	NS
Mmd	4.2	2.4	3.5	2.6	0.435	NS
Ms	2.5	2.0	1.8	1.3	0.131	NS
Go	4.7	1.5	4.8	2.0	0.881	NS
Ag	3.9	1.7	3.3	2.0	0.272	NS

NS, Not significant.

(approximately 3 years) were not significant for any of the examined variables (dental casts, lateral cephalograms, PA cephalograms). These results are consistent with those collected on dental casts of Class II subjects by Arya et al[2] and Bishara et al[3] during the transition from the deciduous to the permanent dentition.

The outcomes of the longitudinal portion of our study can be helpful to clarify the controversial issue of growth trends in subjects with Class II malocclusion with respect to those with normal occlusion. Although Bishara et al[5] noted that the longitudinal comparisons of the growth profiles of the various dentofacial structures in Class II Division 1 and normal subjects were essentially similar (with a final prepubertal observation), Kerr and Hirst,[6] Ngan et al,[7] and Stahl et al[8] found significant deficiencies in mandibular growth in Class II subjects during adolescence. None of these longitudinal studies, however, reported information about the specific contribution of either maxillary skeletal protrusion or mandibular skeletal retrusion to Class II disharmony in their samples. In the study by Stahl et al,[8] an indirect appraisal of the diagnostic features of the examined Class II sample can be derived from the comparison of the starting forms between the Class II and Class I samples. There was a significantly smaller value for the SNB angle in the Class II sample, whereas the average position of the maxilla was almost identical in the Class II and Class I samples. It can be concluded that different prevalence rates for Class II subjects with maxillary skeletal protrusion and mandibular skeletal retrusion might contribute to the explanation of different outcomes in terms of growth trends for Class II malocclusion reported in various studies. It appears that in studies that examined Class II samples with a greater prevalence of maxillary protrusion (as in our study), craniofacial growth features in Class II and Class I subjects were similar, whereas in studies that analyzed Class II samples with a greater prevalence of mandibular skeletal retrusion (as in the study by Stahl et al[8]), significantly smaller increases in mandibular length can be expected in Class II subjects at a circumpubertal stage of skeletal maturation.

CONCLUSIONS

1. Subjects with Class II malocclusion and maxillary skeletal protrusion do not exhibit a significant deficiency in transverse dentoskeletal relationships during the circumpubertal period.
2. Growth trends at puberty in Class II subjects with maxillary protrusion are similar to those in subjects with normal occlusion.

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