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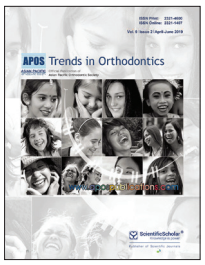

Original Article

Assessing orthodontic treatment need in virtual consultations: A comparative analysis of photographic evaluations and clinical grading

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ABSTRACT

Objectives: The increased use of virtual orthodontic consultations through photographic assessments prompts a need for rigorous evaluation to determine the accuracy and reliability compared to actual orthodontic treatment requirements. This study aimed to establish the consistency of orthodontic treatment need assessments from photographs, comparing evaluations between dental professionals and laypeople and the index of orthodontic treatment need dental health component (IOTN DHC) grading of study models within the same patient cohort.

Material and Methods: A retrospective analysis was conducted using intraoral photographs and digital study models selected from 50 orthodontic patients from a national dental center's records archive, representing specific occlusal traits. Twenty-four assessors were categorized into orthodontists, general dentists, non-orthodontic specialists, orthodontic residents, and laypeople. Intergroup evaluations of treatment needs based on photographs were compared with the IOTN DHC grade of digital study models, employing Kappa statistics and percentage agreement for analysis.

Results: Agreement between photographic assessments and IOTN DHC grades varied from fair to substantial. Orthodontists, orthodontic residents, and general dentists exhibited higher agreement (k = 0.339–0.655) for photographic assessments in comparison to non-orthodontic specialists and laypeople (k = 0.075–0.468) against the IOTN DHC grade. Across all groups, agreement was substantial for photographs depicting crowding (k = 0.493–0.602) and low for spacing (k = −0.039–0.237). Spacing was perceived to require higher treatment intervention than indicated by IOTN DHC across all groups. Orthodontists and general dentists perceived reverse overjet, posterior crossbite, and lateral open bite photographs to necessitate higher treatment intervention compared to laypeople.

Conclusion: Photographic assessments of orthodontic treatment needs showed varying agreement with IOTN DHC grades, with dental professionals demonstrating higher consistency. Agreement was highest for crowding but lower for spacing, reverse overjet, posterior crossbite, and lateral open bite. These findings emphasize the need for improved patient-clinician communication and technological advancements to enhance virtual orthodontic assessments.

Keywords: Orthodontists, Treatment need, Malocclusion, Photographs, Digital study models

INTRODUCTION

Malocclusion prompts individuals to seek orthodontic treatment. Indices, such as the dental esthetic index;[1] index of orthodontic treatment need (IOTN);[2] and index of complexity,

outcome, and need,[3] are employed to assess malocclusion severity and need for intervention. Despite their objective intent, indices have inherent limitations. The inclusion, weighting, and establishment of cut-off points for treatment needs are subjective, relying on the perspectives of expert orthodontists who designed the indices. Variations in methodologies and opinions[4] affect its overall accuracy and applicability across different cultures and countries.[5,6] Other reported limitations include inconsistent terminology,[7] lack of or inappropriate weightings, and failure to include certain occlusal traits.[8]

While clinicians play a pivotal role in determining treatment needs, consideration of the patient's perception of malocclusion is equally crucial, which encompasses perceptual, functional, and social dimensions.[9] However, discrepancies exist between normative orthodontic treatment needs assessed through indices and self-perceived treatment needs reported by patients.[8,10] Existing indices prioritize the clinician's perspective and have complex scoring procedures, in addition to the lack of uniformity in assessment tools used between participant groups. The majority of studies employ the IOTN esthetic component (AC) photographic scale for comparisons, which face limitations including the inadequate representation of anterior-posterior dentofacial imbalances,[11] and omission of certain malocclusions such as Class II division 2 incisor relationships and anterior open bites.[12]

Conventionally, orthodontic treatment planning relies on clinical assessments and study models. In the era of virtual consultations, intraoral photographs have emerged as a valuable tool in assessing malocclusion. Integrating photographs into orthodontic assessments offers simplicity and ease of interpretation, allowing different evaluators to visualize malocclusion features. Previous studies reported lower treatment need assessments using facial photographs for evaluation,[13-15] which may be attributed to the limitation of extraoral facial photographs to adequately visualize intraoral occlusal traits. In contrast, studies combining IOTN scores from plaster casts with extraoral and intraoral images demonstrated fair to substantial agreement.[13,16] However, these evaluations were conducted with orthodontists, overlooking the perspectives of other dental professionals and laypeople.

This study aims to evaluate the consistency of orthodontic treatment need assessments between dental professionals and laypeople using intraoral photographs and compare them with IOTN dental health component (DHC) grades of orthodontic study models. By highlighting the perceptual differences, this study explores the clinical implications and opportunities in orthodontic treatment planning, particularly in virtual consultation.

MATERIAL AND METHODS

Ethical approval for the study was obtained from the SingHealth Centralized Institutional Review Board (RC2018/3052).

The study population was recruited from the National Dental Centre Singapore. A power calculation based on the proposed method by Cicchetti[17] produced a minimal required sample size of 20 subjects. In total, 50 subjects representing a range of distinct malocclusion traits of varying severity were included in the study. The malocclusion traits were crowding, spacing, posterior crossbite, anterior crossbite, increased overjet, reverse overjet, anterior open bite, lateral open bite, and deep overbite [Figure 1]. All were in full permanent dentition. Data were retrospectively collected by means of intraoral photographs and digital study models. These were obtained as part of standard clinical procedures by trained clinicians and assistants before orthodontic treatment.

The IOTN DHC was used to assess orthodontic treatment needs and malocclusion traits. Each subject's digital study model was examined using 3 Shape OrthoAnalyzer™ (3Shape, Copenhagen, Denmark) software by an investigator (L.Y) who underwent calibration with an experienced orthodontist trained in an occlusal index calibration course by Professor Stephen Richmond. The investigator recorded the most severe occlusal trait as the DHC score and corresponding treatment need grade. Detailed measurements for applicable trait specifications were recorded to the nearest 0.5 mm for each case. The DHC grade and measurements were repeated after a 15-day interval.

Intraoral photographs, featuring a frontal and a right buccal view, were assembled for each subject. The photographs were taken with the use of cheek retractors at maximum intercuspation before the start of orthodontic treatment. The images were converted from color to grayscale using PowerPoint software (Microsoft, Redmond, Wash) to eliminate color influence on treatment need assessments.

Twenty-four assessors, comprising orthodontists, orthodontic residents, non-orthodontic specialists, general dental practitioners, and laypeople, participated in the study. Assessors independently rated photographs of each subject on a scale of great, moderate, or no need for orthodontic treatment. Individual assessments were conducted in separate sessions without time constraints. Following a 4-week washout period, four assessors were randomly selected to repeat the evaluation for reliability testing.

Statistical analysis

Statistical analysis was conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA) with a significance level set at 5%. Cohen's Kappa statistics were employed to

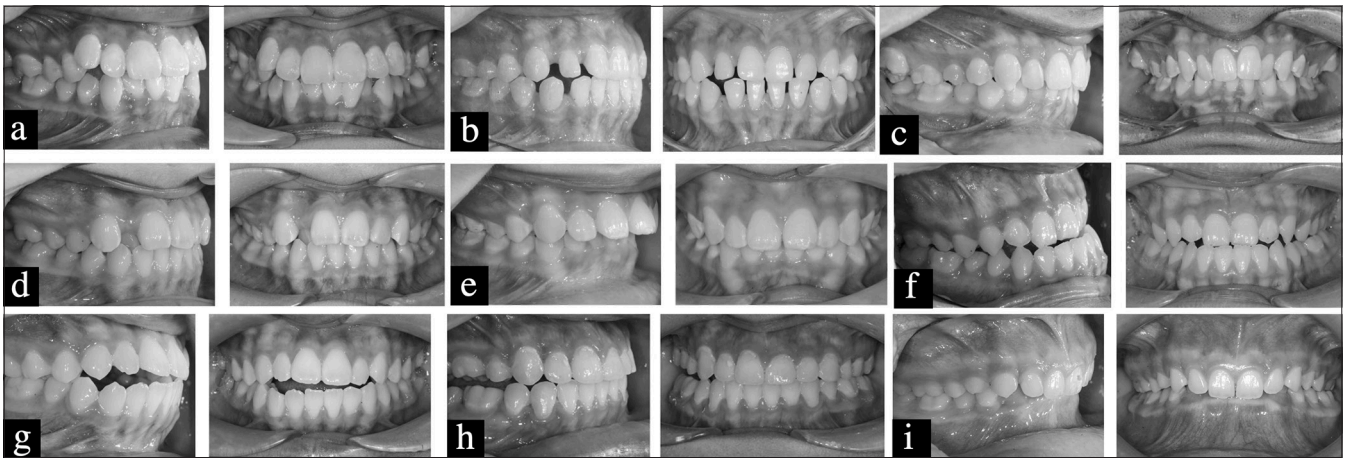

Figure 1: Example of oral photographs with buccal and frontal views representing malocclusion traits of (a) crowding, (b) spacing, (c) posterior crossbite, (d) anterior crossbite, (e) increased overjet, (f) reverse overjet, (g) anterior open bite, (h) lateral open bite, and (i) deep overbite.

assess agreement for treatment needs between intraoral photographs and IOTN DHC grades, assessors, groups, and intra-rater reliability. The agreement was evaluated for the entire set of 50 cases and after categorization into individual malocclusion traits. Fleiss' Kappa statistics were used for intra-group agreement. Percentage agreement was calculated for cases without agreement with IOTN DHC grades. Kappa coefficients were evaluated using the guidelines outlined by Landis and Koch.[18]

RESULTS

Agreement between photographic assessments and IOTN DHC grade ranged from slight (k = 0.075) to substantial (k = 0.655) for dental professionals [Table 1] and laypeople [Table 2]. Fair agreement was observed among the majority of the assessors with IOTN DHC. The percentage agreement for photographic assessments with IOTN DHC grade varied from 40.0% to 78.0%. Orthodontists (k = 0.454), orthodontic residents (k = 0.450), and general dentists (k = 0.457) exhibited higher agreement in photographic assessments with IOTN DHC grade compared to laypeople (k = 0.309) and non-orthodontic specialists (k = 0.225).

Agreement between orthodontists and laypeople (k = 0.280) and general dentists and laypeople (k = 0.208) was fair.

Considerable variation in treatment need agreement was observed across all occlusal traits when comparing photographic assessments with IOTN DHC grade. High agreement was noted for crowding (k = 0.493–0.602) across all groups, whereas spacing (k = −0.039–0.237) and lateral open bite (k = 0.093–0.263) exhibited lower agreement [Table 3].

Crowding (71.0%) and posterior crossbite (78.9%) photographs had the highest agreement with IOTN DHC grades among all orthodontists, general dentists, and laypeople. For cases without agreement with IOTN DHC grades, all photographs depicting spacing were assessed as having higher treatment needs by orthodontists (61.0%) laypeople (48.5%), and the majority of general dentists (44.7%). In addition, a higher proportion of photographs featuring anterior open bite (32.2%) and deep overbite (37.8%) were rated with higher treatment needs than indicated by the IOTN DHC grade across all participant groups. In contrast, all photographs illustrating anterior crossbite were consistently assessed with lower treatment needs by orthodontists (33.3%), general dentists (26.7%), and laypeople (58.3%) than indicated by the IOTN DHC grade. Similarly, increased overjet photographs received lower treatment need ratings from orthodontists (26.7%), general dentists (26.7%), and laypeople (45.0%). Inter-group variability was found for reverse overjet, posterior crossbite, and lateral open bite. Orthodontists and general dentists assessed these malocclusion traits with higher treatment needs, whereas laypeople rated them with lower treatment needs [Table 4].

Intragroup agreement was moderate for orthodontic residents (k = 0.485) and fair for non-orthodontic dental specialists (k = 0.364), orthodontists (k = 0.354), and laypeople (k = 0.246). Intra-rater reliability ranged from moderate (k = 0.431) to substantial (k = 0.693) for four randomly selected participants. Intraexaminer reliability of scoring of the DHC of IOTN was substantial (k = 0.953).

DISCUSSION

The adoption of virtual orthodontic consultations has led to a deviation from traditional in-person clinical examinations. Clinical photography and photogrammetry are important tools for virtual treatment planning and follow-ups of

Table 1: Agreement of treatment need from photographic assessments by dental professionals and IOTN DHC grades from digital study models presented as Cohen's kappa coefficient and *P* value and percentage of agreement (%).

Dental professionals	Mean kappa (range)	*P*-value	%
Total	0.353 (0.197–0.655)		
Orthodontists	0.454 (0.419–0.506)		
Orthodontist 1	0.437	<0.001	64.0
Orthodontist 2	0.506	<0.001	68.0
Orthodontist 3	0.419	<0.001	64.0
Orthodontic residents	0.450 (0.395–0.522)		
Orthodontic resident 1	0.522	<0.001	70.0
Orthodontic resident 2	0.395	<0.001	62.0
Orthodontic resident 3	0.434	<0.001	64.0
Non-orthodontic specialists	0.225 (0.197–0.251)		
Non-orthodontic specialist 1	0.197	0.025	44.0
Non-orthodontic specialist 2	0.251	0.010	50.0
Non-orthodontic specialist 3	0.228	0.011	48.0
General dentists	0.457 (0.339–0.655)		
General dentist 1	0.655	<0.001	78.0
General dentist 2	0.339	<0.001	60.0
General dentist 3	0.378	<0.001	60.0

Strength of agreement for the kappa coefficient: 0: None, 0.01–0.20: Slight, 0.21–0.40: Fair, 0.41–0.60: Moderate, 0.61–0.80: Substantial, 0.81–1.00: Almost perfect agreement (Landis and Koch, 1977). IOTN: Index of orthodontic treatment need, DHC: Dental health component

Table 2: Agreement of treatment need from photographic assessments by laypeople and IOTN DHC grades from digital study models presented as Cohen's kappa coefficient and *P* value and percentage of agreement (%).

Laypeople	Mean kappa (range)	*P*-value	%
Total	0.309 (0.075–0.468)		
Layperson 1	0.075	0.454	40.0
Layperson 2	0.123	0.230	62.0
Layperson 3	0.432	<0.001	62.0
Layperson 4	0.262	0.008	52.0
Layperson 5	0.468	<0.001	66.0
Layperson 6	0.318	0.001	54.0
Layperson 7	0.426	<0.001	62.0
Layperson 8	0.442	<0.001	50.0
Layperson 9	0.251	0.010	50.0
Layperson 10	0.315	0.001	54.0
Layperson 11	0.429	<0.001	62.0
Layperson 12	0.177	0.086	48.0

Strength of agreement for the kappa coefficient: 0: None, 0.01–0.20: Slight, 0.21–0.40: Fair, 0.41–0.60: Moderate, 0.61–0.80: Substantial, 0.81–1.00: Almost perfect agreement (Landis and Koch, 1977).
IOTN: Index of orthodontic treatment need, DHC: Dental health component

various orthodontic treatment procedures. The reliance on intraoral photographs submitted through digital platforms necessitates an accurate interpretation of the type and severity of malocclusion from these images to determine and recommend appropriate treatment plans.

Our findings indicated that the agreement between orthodontic treatment needs assessed from intraoral photographs and IOTN DHC grades was found to be lower than that reported in studies comparing plaster casts and their digital images[13] or intraoral and extraoral photographs.[16] These studies were conducted with orthodontists, whose specialized expertise may have contributed to higher agreement levels. Consistent with this, our study observed higher agreement among orthodontists, orthodontic residents, and general dentists compared to non-orthodontic specialists and laypeople. This underscores the influence of professional background, education, and experience on the accuracy of photographic assessments of malocclusion.

Patient perceptions of malocclusion and orthodontic treatment needs are crucial for the acceptance and success of orthodontic treatment. We investigated the agreement among orthodontists, general dentists, and laypeople, given their higher levels of interaction in clinical settings. Laypeople were recruited by convenience sampling. Although sociodemographic characteristics were not controlled, gender,[19,20] ethnicity,[20,21] and history of orthodontic treatment[22] were not found to influence the perception of malocclusion and treatment need. Our study found lower agreement between orthodontists, general dentists, and laypersons than in previous studies, which may be attributed to differences in assessment tools. Previous studies used Visual Analog Scales by utilizing photographs from the AC of IOTN[9,12,23-25] or questionnaires on the patient's own malocclusion[26-28] to measure laypeople's perception of treatment needs against clinical examinations or IOTN DHC scores by dental professionals, whereas our study employed

Table 3: Agreement of treatment need for individual occlusal traits from photographic assessments by orthodontists, general dentists, and laypeople and IOTN DHC grades from digital study models presented as Cohen's kappa coefficients.

Occlusal trait	Orthodontists (*n*=3)		General dentists (*n*=3)		Laypeople (*n*=12)	
	Mean kappa (range)		Mean kappa (range)		Mean kappa (range)	
Crowding	0.517	(0.276–0.741)	0.602	(0.533–0.741)	0.493	(−0.05–1.00)
Spacing	−0.039	(−0.250–0.333)	0.149	(−0.125–0.571)	0.237	(−0.25–1.00)
Posterior crossbite	0.515	(0.00–1.00)	0.333	(0.00–1.00)	0.347	(−0.364–1.00)
Increased overjet	0.286	(0.286–0.286)	0.651	(0.286–1.00)	0.041	(−0.364–1.00)
Reverse overjet	0.534	(0.375–0.643)	0.424	(0.00–0.688)	0.270	(−0.071–0.444)
Anterior crossbite	0.389	(0.00–1.00)	0.630	(−0.111–1.00)	0.138	(−0.136–1.00)
Anterior open bite	0.444	(0.333–0.667)	0.333	(0.00–1.00)	0.388	(−0.063–0.688)
Lateral open bite	0.263	(−0.250–0.706)	0.093	(−0.25–0.412)	0.134	(−0.333–0.688)
Deep overbite	0.438	(0.063–1.00)	0.444	(−0.111–1.00)	0.198	(−0.25–0.688)

Strength of agreement for the kappa coefficient: 0: None, 0.01–0.20: Slight, 0.21–0.40: Fair, 0.41–0.60: Moderate, 0.61–0.80: Substantial, 0.81–1.00: Almost perfect agreement (Landis and Koch, 1977). IOTN: Index of orthodontic treatment need, DHC: Dental health component

Table 4: Percentage agreement of treatment need for individual occlusal traits from photographic assessments by orthodontists, general dentists, and laypeople and IOTN DHC grades from digital study models – higher treatment need than IOTN DHC grade, same as IOTN DHC grade and lower treatment need than IOTN DHC grade.

Occlusal trait	Orthodontists (*n*=3)			General dentists (*n*=3)			Laypeople (*n*=12)		
	Higher (%)	Same (%)	Lower (%)	Higher (%)	Same (%)	Lower (%)	Higher (%)	Same (%)	Lower (%)
Crowding	9.5	71.4	19.0	19.0	76.2	4.8	8.3	65.5	26.2
Spacing	61.0	39.0	0.0	44.4	44.4	11.0	48.6	51.4	0.0
Posterior crossbite	6.7	86.7	6.7	13.3	86.7	0.0	1.7	63.3	35.0
Increased overjet	13.3	60.0	26.7	0.0	73.3	26.7	11.7	43.3	45.0
Reverse overjet	20.0	73.3	6.7	20.0	73.3	6.7	15.0	55.0	30.0
Anterior crossbite	0.0	66.7	33.3	0.0	73.3	26.7	0.0	41.7	58.3
Anterior open bite	33.3	66.7	0.0	40.0	60.0	0.0	23.3	60.0	16.7
Lateral open bite	26.7	53.3	20.0	53.3	40.0	6.7	13.3	46.7	40.0
Deep overbite	40.0	60.0	0.0	40.0	60.0	0.0	33.3	46.7	20.0

IOTN: Index of orthodontic treatment need, DHC: Dental health component

a standardized set of photographs across all assessors. This approach aimed to reduce variability and ensure a uniform basis for evaluation.

Disparities in the perception of individual occlusal traits were evident, consistent with existing literature.[29] Crowding exhibited the highest agreement with IOTN DHC grades, reflecting its visibility and significant esthetic and orthodontic implications. Conversely, spacing showed the lowest agreement across all groups and was perceived to require higher treatment intervention than indicated by IOTN DHC. This discrepancy suggests that the IOTN criteria which focus on dental health impact may not adequately reflect the concern[24,30] and the impact of spacings on quality of life.[31]

Further discrepancies were observed for reverse overjet, posterior crossbite, and lateral open bite. Orthodontists and general dentists rated these traits as requiring higher treatment intervention than indicated by IOTN DHC, whereas laypeople rated them as less severe. Previous studies have highlighted that orthodontists place greater emphasis on the esthetic impact of reverse overjet[32] and may categorize posterior open bite as a higher treatment priority than the IOTN DHC.[7] In addition, traits affecting posterior teeth, such as posterior crossbite and lateral open bite, are less visible,[33] and therefore, less concerning to laypeople.[34] This finding highlights the potential variations in photographic assessments of orthodontic treatment needs among different groups and the difference in perspective between the clinician and patient on the importance of correcting different types of malocclusions. While dental professionals can more accurately evaluate orthodontic treatment needs from photographs in alignment with IOTN DHC indications, they may prioritize the correction of certain malocclusions such as reverse overjet, posterior crossbite, and lateral open bite, which may not be what the patient wants or understands.

A disconnect between the goals of the patient and the clinician may lead to the patient being less cooperative, tired, and disinterested in the procedures, eventually resulting in patient burnout.[35] Effective communication between the clinician and patient is essential to understand the patient's needs, align treatment plans with patient expectations, and achieve satisfactory outcomes.

The limitations of our study include the challenges of assessing malocclusion traits from photographs. The use of photographs displaying distinct occlusal traits may oversimplify the complex interplay of multiple traits and their impact on treatment needs. In addition, the position and angle of the camera may also lead to an underestimation of discrepancies, particular in the anterior-posterior dimension, and may render posterior malocclusions less visible. While two-dimensional photographic assessments have utility in virtual consultations, we acknowledge their limitations for posterior malocclusions and occlusal discrepancies. Future integration of advanced imaging technologies, such as three-dimensional imaging technology could enhance visualization and address these limitations, providing a more comprehensive assessment of orthodontic treatment needs.

CONCLUSION

1. Agreement for treatment needs based on photographic assessments compared to IOTN DHC grade ranged from slight to substantial, with higher agreement among orthodontists, orthodontic residents, and general dental practitioners.
2. Photographs of crowding demonstrated the highest agreement with IOTN DHC grades, while spacing showed the lowest agreement.
3. Orthodontists and general dentists assessed photographs of reverse overjet, posterior crossbite, and lateral open bite as requiring higher treatment intervention than laypeople.

This study explores the complexities of assessing orthodontic treatment needs using photographs in virtual consultations and emphasizes the importance of considering professional expertise and technological advances. Three-dimensional imaging may improve accuracy and bridge disparities in perception, refining virtual orthodontic assessments and ensuring optimal patient communication in the digital era.

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