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Original article

Cone-beam computed tomography integration in clear aligner treatment planning: A cross-sectional study exploring practices and perceptions among orthodontists and general practitioners

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Highlights

- CBCT integration commonly influences orthodontic treatment decisions.
- Orthodontists reported increased diagnostic confidence with CBCT-integrated software.
- Impacted teeth and root-level expansion are key indications for CBCT integration.
- Cost and radiation exposure remain barriers to broader clinical adoption.

Summary

Objectives > To assess the practices and perceptions of orthodontists (OT) and general dentists (GP) regarding the usage of Cone-Beam Computed Tomography (CBCT) integration in orthodontic treatment planning with Clear Aligner Therapy (CAT).
Design > Cross-sectional study.
Methods > A web-based survey invited orthodontic practitioners from Canada, Brazil, and Spain to participate. The survey was administered between April and August 2024 and assessed the integration of CBCT with CAT software for orthodontic planning. Descriptive statistics, along with bivariate and regression analysis, were used to analyze the collected data.
Results > A total of 312 clinicians participated in the study, with 92.9% providing CAT and a median of 300 cases treated annually. CBCT scans were commonly used for specific cases in initial orthodontic records (OT: 73%, GP: 54%), while CBCT integration was utilized by 51% of OT and 77% of GP. Most users reported confidence in diagnosis and treatment planning with the

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integration tool, particularly for evaluating impacted teeth (OT: 91%, GP: 100%, OR: 100%) and planning dental expansion (OT: 76%, GP: 100%). Nearly 90% of participants found the integration useful in treatment decision-making, with 75% of OT indicating it could alter treatment plans.
Conclusions > The integration of CBCT into orthodontic planning with CAT is perceived as advantageous, especially for complex cases involving impacted teeth, skeletal discrepancies, and craniofacial disorders. 3D visualization capabilities to provide detailed 3D visualization of hard and soft tissue profiles may enhance diagnostic accuracy and treatment planning, especially for experienced orthodontists.

Introduction

Clear Aligner Therapy (CAT) has become very popular in the last 5–10 years, and it is actually the most widely used treatment option in orthodontics worldwide [1–3]. One of the challenging aspects of using a clear aligners system is its considerable variation in the predictability of tooth movement [4,5]. Systematic reviews over the years have consistently found no strong conclusions about the ability of this system to predict tooth movement, in which upper distalization was the most predictable movement and extrusion was the least predictable one [6]. CBCT integration has been proposed as a new tool for the treatment-planning platform of this CAT system. Using a three-dimensional (3D) advanced imaging modality could improve the evaluation of tooth position and surrounding structures, allowing the assessment of these structural features to accomplish practitioners' treatment goals, avoiding undesirable effects such as bone and dental resorption, as well as the need for refinements, which prolong the overall treatment duration [7,8].

To date, the use of CBCT integration tool on the ClinCheck® Pro software (ClinCheck® Pro, Align Technology, Santa Clara, CA, USA) has shown better predictability in torque assessment, although there is a scarcity of further studies evaluating this integration [9]. In addition to understanding the effectiveness of CBCT integration in treatment planning, it is essential to screen the perceptions and practices of dental professionals (i.e., orthodontists and general dentists) while using this new system, as well as the differences between perceived preferences in both professional categories. Also, the role of case complexity, and which common features may influence the practices of dental professionals in orthodontic treatment planning and the usage of CBCT must be investigated [10,11]. These features must also be evaluated along with the overall effectiveness of this tool. Thus, this study assessed the practices and perceptions of orthodontists and general dentists adding the importance and usage of CBCT integration with orthodontic planning software.

Methods

The Research Ethics Board at the University of Alberta in Canada approved this multi-country cross-sectional survey study under protocol number Pro00132448. The study was conducted in accordance with the STROBE guidelines for observational studies [12] and the Consensus-Based Checklist for Reporting of Survey Studies (CROSS) [13].

Adherence to both guidelines is presented in Online supplements 1 and 2.

Survey design and validation

A survey was developed and validated to focus on the usefulness of adopting the CBCT integration tool on the ClinCheck® Pro software (Align Technology, Santa Clara, CA, USA) to clinical practice. Particularly context-specific items related to perceptions and practices regarding the use of CBCT scans and with 3D imaging integration during treatment with CAT were developed based on a previous questionnaire and from the experience of our research team [3]. Expert feedback was sought to ensure content validity. This process included three phases. First, an expert in survey development and validation provided feedback on the survey length, structure, dimensions of the main construct, and items (e.g., clarity, relevance). Second, certified orthodontists (OT) and general dentists' practitioners (GP) with experience in CAT (n = 7) checked the clarity and relevance of the survey items. Lastly, "lay experts" (n = 7), who were not orthodontists, were conveniently selected to provide feedback. These "lay experts" commented on the clarity of items, length, structure of the survey, and their experiences completing it. At the end of each phase, the research team discussed the feedback received and made changes accordingly. The retest assessment to validate questionnaire reliability involved the same orthodontists and lay experts participating in the pilot study.

The final survey consisted of 44 questions divided into three sections: demographics, CBCT utilization, and CBCT integration in orthodontic planning (Online supplements 3).

Study participants and data collection

On a multi-country approach, OT and GP from private dental practices and academia registered in Canada, Brazil, and Spain were invited to participate and selected by convenience. Any licensed general dentist or orthodontists with active clinical practice in the country investigated were eligible to participate in the study. Licensed professionals that have not had any experience with CAT appliances were excluded. The survey was sent to all OTs with active practice in Canada and to potential Invisalign® providers in Spain and Brazil, as identified via web search.

Data were collected between April to August 2024 by email through the SurveyMonkey platform (San Mateo, CA, USA), as well as by text messages sent using WhatsApp (Meta Platforms, Inc., Menlo Park, California, USA). In addition, ads on Instagram (Meta Platforms, Inc., Menlo Park, California, USA) were used to reach specialists and additional general dentists. Three reminders were sent every second week to encourage participation. Acceptance to participate in the survey implied consent.

Data analysis

To assess the achieved statistical power to evaluate the use of CBCT among OT and GP in the survey, a post hoc analysis was performed to compute using G* Power (version 3.1, Dusseldorf, Germany), considering an effect size of 1.5 and an $\alpha = 0.05$.

Survey data were analyzed using descriptive and bivariate statistics. The Chi^2 and independent *t*-test were used to analyze the demographic differences associated with utilizing the CBCT-integrated tool. The SPSS statistical package for the social sciences (version 25; IBM, Armonk, NY, USA) was used for data analysis. The Word Clouds were generated (Word Cloud Maker, Barcelona Field Studies Center, available at https://geographyfieldwork.com/WordCloudMaker.html) to improve data visualization of perceived risks and drawbacks of the CBCT integration tool.

Results

This cross-sectional study was conducted from April to August 2024. A total of 312 clinicians responded: 43 were GP and 269 were OT. Most respondents self-identified as females (57%), as shown in *figure 1*. The achieved power was 0.99

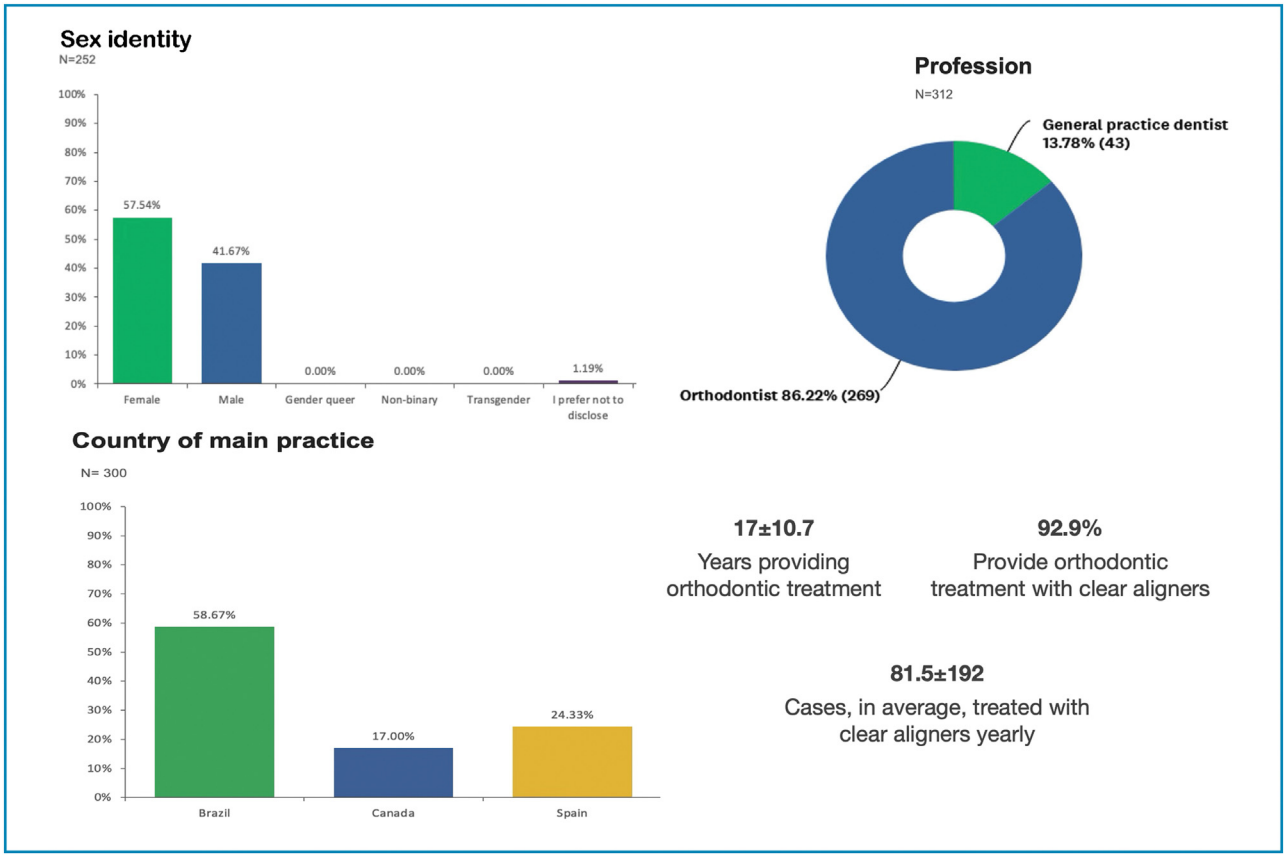

FIGURE 1

Demographic features of survey respondents (*n* = 312)

for orthodontists and 0.35 for GPs. 58.6% of the respondents were from Brazil, 24.3% from Spain, and 17% from Canada. The average experience with orthodontic practice was 17.3 ± 10.7 years, and 7.6 ± 5.2 years with CAT.

Use of CBCT scans and CBCT integration in ClinCheck®

Most respondents reported using CBCT scans in their private practice (OT = 77%, GP = 75%), while more than half reported using it in specific clinical cases to initial records (OT = 73%, GP = 60%). Most orthodontists also reported using CBCT scans in specific clinical cases for progress orthodontic records (OT = 66%), although almost half of GP reported not using it (GP = 40%) (Online supplements 4 figures S1 and S2).

Overall, the percentage of orthodontists in Spain using CBCT scans was higher when compared to Brazil and Canada (Brazil = 73%, Canada = 79%, Spain = 93%, $P = 0.01$). No difference was observed regarding the use of CBCT integration tool among GP of the three countries ($P = 0.23$) (*table I*).

TABLE I

Differences in the distribution of demographic and CBCT scans practices according to ClinCheck® integration utilization

ClinCheck CBCT integration utilization			
	Yes[a]	No[a]	*P*-value*
Profession			
General practice dentist	10 (9.80%)	3 (3.4%)	0.17
Orthodontist	82 (80.4%)	78 (87.6%)	
Orthodontic resident	8 (7.8%)	8 (9%)	
Other specialist (please specify)	2 (2%)	0 (0%)	
Country of primary practice			
Brazil	46 (45.1%)	52 (58.4%)	0.001
Canada	28 (27.5%)	6 (6.7%)	
Spain	28 (27.5%)	31 (34.8%)	
Other country	0 (0%)	0 (0%)	
Sex			
Male	50 (49%)	52 (58.4%)	0.41
Female	51 (50%)	36 (40.4%)	
Transgender	0 (0%)	0 (0%)	
Non-binary	0 (0%)	0 (0%)	
Gender queer	0 (0%)	0 (0%)	
I prefer not to disclose	1 (1.0%)	1 (1.0%)	
For how many years have you been providing orthodontic treatment?	16.6 ± 1.1 (14.3, 19.1)	19.4 ± 1.1 (17.3, 21.5)	0.09
For how many years have you been providing orthodontic treatment with clear aligners?	7.2 ± 0.5 (6.2, 8.2)	8.6 ± 0.5 (7.4, 9.8)	0.06
How many cases do you treat with clear aligners yearly?	49.8 ± 8.7 (32.9, 67.8)	133.9 ± 33 (68.3, 199.6)	0.003
CBCT utilization			
Do you utilize CBCT scans for routine orthodontic initial records?			
No	14 (13.7%)	4 (4.5%)	0.02
Yes, for all patients (children, adolescents, and adults)	11 (10.9%)	22 (24.7%)	0.001
Yes, but only for all children patients	0 (0%)	0 (0%)	N/A
Yes, but only for all adolescent patients	1 (1.0%)	1 (1.0%)	0.71
Yes, but only for all adult patients	9 (8.9%)	7 (7.9%)	0.5

Table I **(Continued).**

ClinCheck CBCT integration utilization	Yes[a]	No[a]	*P*-value[*]
Yes, but only for specific clinical cases (e.g., patients with impacted teeth, supernumerary teeth, transpositions, craniofacial asymmetry, etc.)	74 (73.3%)	62 (69.7%)	0.34
Do you utilize CBCT scans for routine orthodontic progress records?			
No	27 (26.5%)	26 (29.2%)	0.39
Yes, for all patients (children, adolescents, and adults)	8 (7.8%)	13 (14.6%)	0.1
Yes, but only for all children patients	0 (0%)	0 (0%)	N/A
Yes, but only for all adolescent patients	0 (0%)	0 (0%)	N/A
Yes, but only for all adult patients	2 (2%)	3 (3.4%)	0.66
Yes, but only for specific clinical cases (e.g., patients with impacted teeth, supernumerary teeth, transpositions, craniofacial asymmetry, etc.)	67 (65.7%)	49 (55.1%)	0.08
Do you utilize CBCT scans for routine orthodontic final records?			
No	72 (70.6%)	45 (51.1%)	0.005
Yes, for all patients (children, adolescents, and adults)	4 (3.9%)	9 (10.2%)	0.07
Yes, but only for all children patients	0 (0%)	1 (1.0%)	0.46
Yes, but only for all adolescent patients	1 (0%)	1 (1.0%)	1.46
Yes, but only for all adult patients	0 (0%)	2 (2.0%)	0.21
Yes, but only for specific clinical cases (e.g., patients with impacted teeth, supernumerary teeth, transpositions, craniofacial asymmetry, etc.)	27 (26.5%)	32 (36.4%)	0.09

*: Chi^2 test/Mann-Whitney test, when applicable; [a]: mean, standard deviations and 95% Confidence Intervals were included for continuous variables. Sample size and percentages: *n* (%) were included for nominal variables. CBCT: cone-beam computed tomography.

The CBCT integration tool was described to be used among patients presenting complex oral and maxillofacial disorders by two thirds of GP and OT (OT = 71%, GP = 67%). Most respondents reported using it for dental examination of impacted teeth (OT = 91%, GP = 100%) and to plan dental expansion at the root level (OT = 76%, GP = 67%), (*figure 2*). The respondents also identified some risks and drawbacks while using this tool in clinical practice, including the cost and ionizing radiation exposure to the patient (*figure 3*).

Most OT and GP agreed (OT = 77%, GP = 100%) that this tool may enhance their ability to treat more complex CAT cases. Also, most orthodontists shared that their treatment plan would be very likely or somewhat likely to change if they incorporated the CBCT tool (OT = 75%) (Online supplements 4 figures S3 and S4).

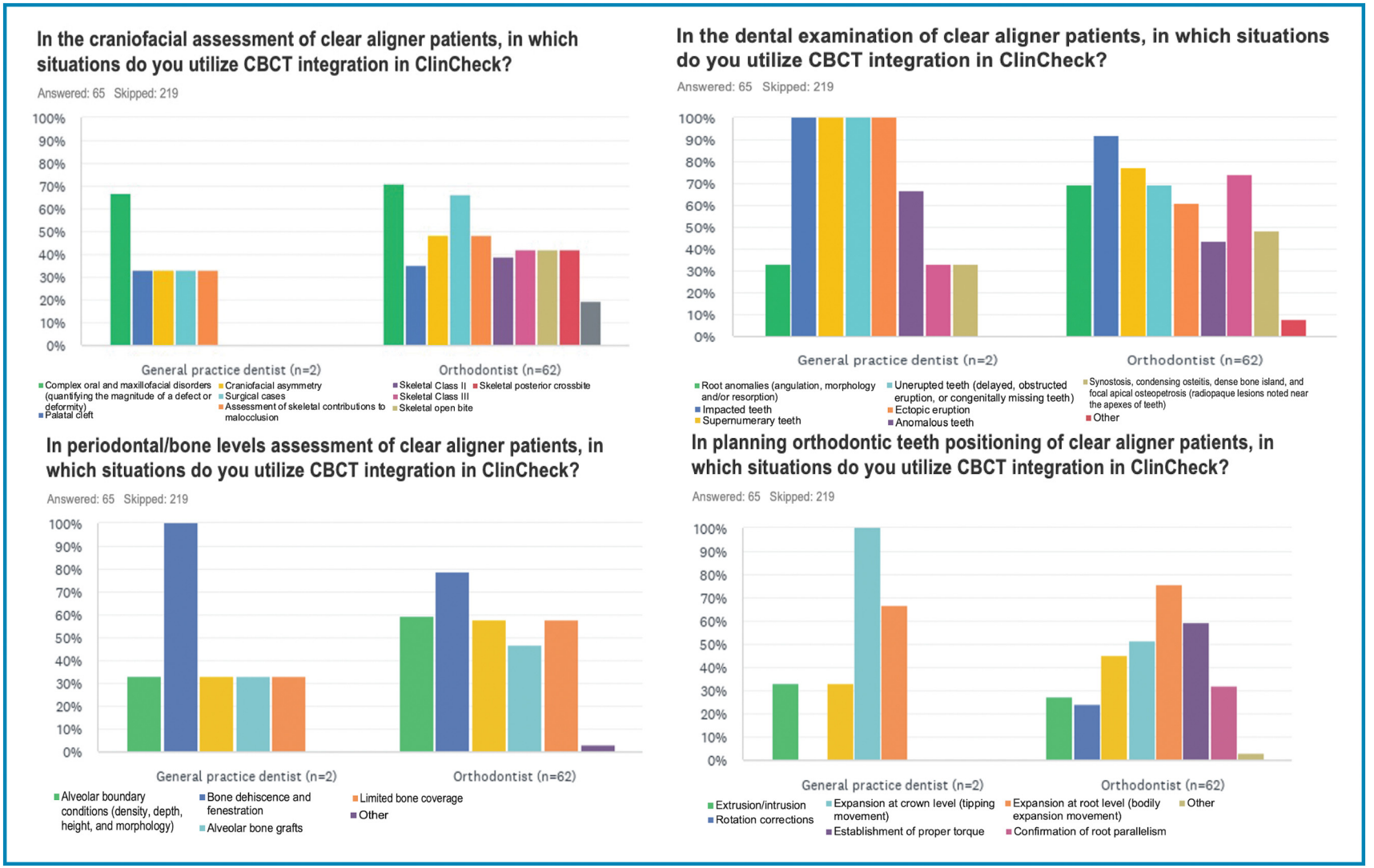

FIGURE 2

Scenarios of CBCT integration use in ClinCheck® among respondents

FIGURE 3

Representation of risks or drawbacks for patients (A) and clinicians (B) associated with using CBCT integration in ClinCheck®

Perceptions regarding future use of CBCT scans and CBCT integration in ClinCheck®

More than a half of participants will likely consider using CBCT scans (OT = 68%, GP = 60%) for specific cases of adult patients for initial orthodontic records. Most respondents would feel more confident diagnosing and planning treatment cases using the CBCT integration tool (OT = 67%, GP = 81%) (*figure 4*, Online supplements 4 figure S5).

A few future utilizations of CBCT integration in ClinCheck® were reported by participants, including quantifying the magnitude of a defect or deformity of a complex oral and maxillofacial disorder (OT = 79%, GP = 50%), surgical cases (OT = 74%, GP = 56%), assessing impacted teeth (OT = 88%, GP = 69%), and evaluating bone dehiscence and fenestration (OT = 69%, GP = 56%) (*figure 5*).

Around half of the participants reported that CBCT integration would be somewhat useful for treatment planning (55%), and the vast majority agreed that this tool might improve patient communication (Online supplements 4 figures S6–S8).

CBCT integration tool utilization, demographic factors and 3D imaging use

The group of participants who used the integration tool showed a higher mean of annually treated cases when compared to the non-users (ClinCheck® CBCT tool users = 133.9 $\pm$ 33 cases/year, ClinCheck® CBCT tool non-users = 49.8 $\pm$ 8.7, P = 0.03). Additionally, participants with experience using the tool also used CBCT scans more frequently during the assessment of initial orthodontic records among all patients (*table I*).

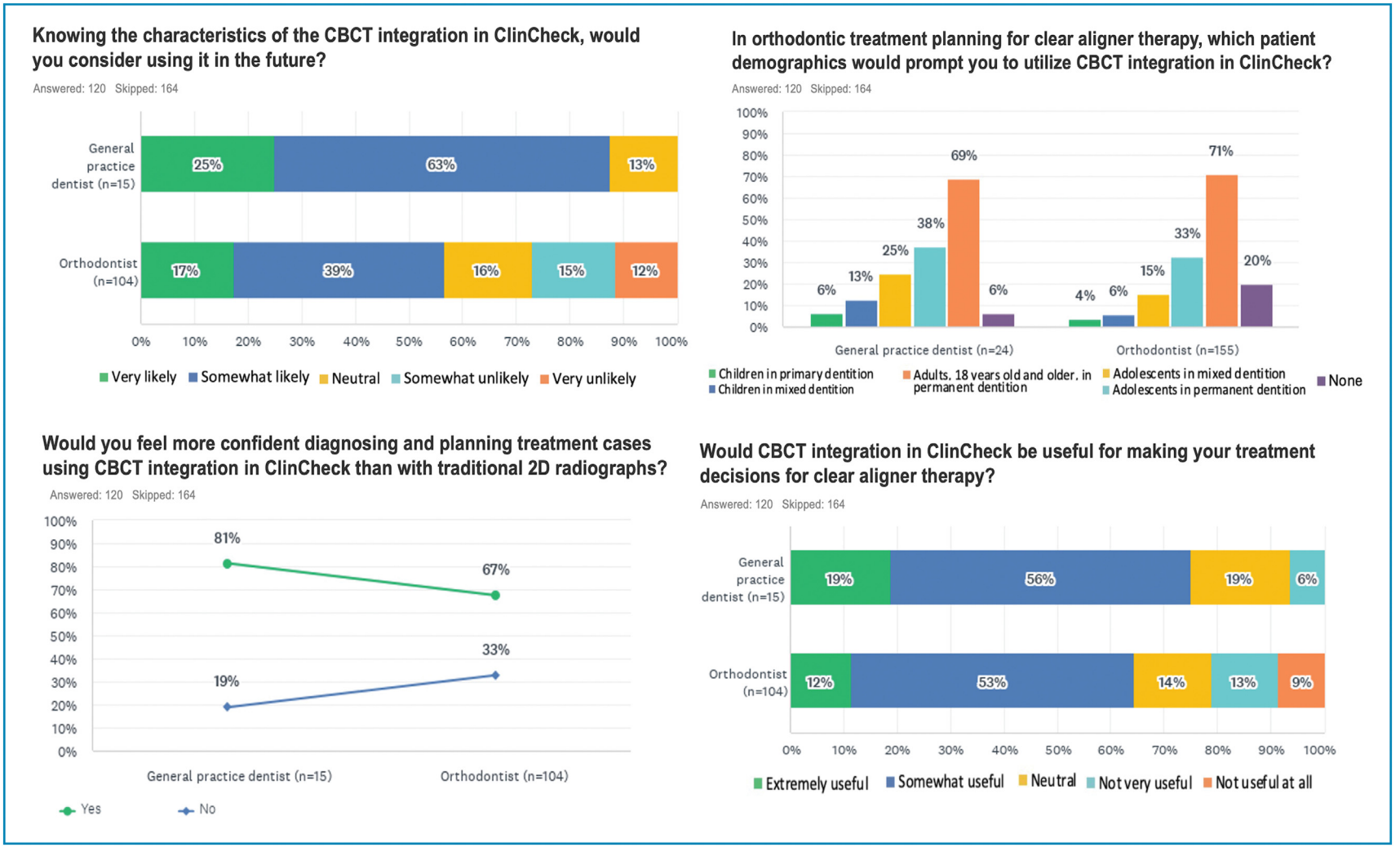

FIGURE 4

Perceptions regarding future use of the CBCT integration tool

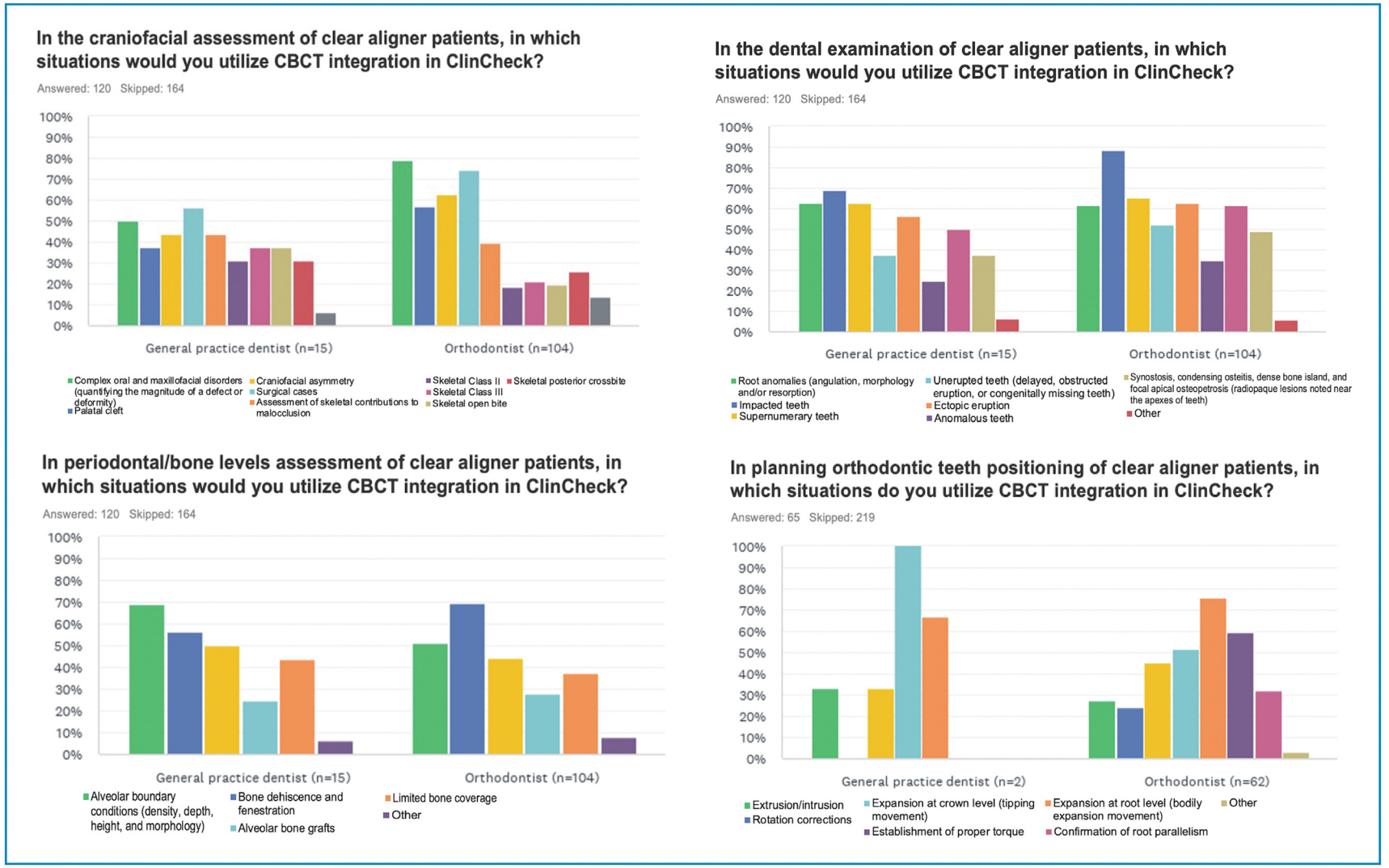

FIGURE 5

Scenarios of which participants would use the CBCT integration tool

Discussion

The results of this study highlight that CBCT is most commonly used in specific clinical cases during orthodontic initial records retrieval across all professional categories surveyed. Orthodontists who integrate CBCT with CAT software reported feeling more confident during treatment planning and indicated that they primarily use the tool for assessing skeletal or root positions. Some perceived risks to patients were identified, including overlooking incidental radiographic findings due to the cost of OMFR reports (that is not required for 2D conventional radiographs) and exposure to ionizing radiation. Regarding the future use of the integration, respondents anticipated potential benefits to current users, such as the assessment of root anomalies, ectopic eruption, and transposition, that have not been widely recognized.

Clinician use of CBCT in initial records and during treatment

Our results indicate that OT tended to incorporate it during initial records and to adopt CBCT imaging during orthodontic treatment progression for specific clinical cases. Previous research also suggests that OT generally consider conventional radiographs sufficient for most cases when taking final orthodontic records [9,14]. When asked about their opinions on potential changes in treatment plans and benefits for patients using CBCT integration, most participants agreed that their initial plans could have changed with the new software. This aligns with a previous study, which found that up to 43% of dentists will alter their patients' CAT treatment plan upon viewing root morphology, as opposed to seeing only the crown [15]. This suggests that CBCT might provide additional diagnostic information, leading to adjustments in treatment strategies. The study highlights several potential benefits of integrating CBCT into orthodontic planning for practitioners.

A previous study stated that 3D radiographs assist clinicians in developing better CAT treatment plans [16]. The data suggests that the sample of GPs and most OTs agree that the integration would improve their ability to make better treatment decisions when using CAT. Nevertheless, as the body of evidence supporting the clinical benefits of the advanced imaging integration continues to grow, more clinicians may be persuaded of its value, even for less complex cases [17,18].

Benefit of CBCT integration in complex cases

This study reveals that the most commonly perceived reasons for utilizing CBCT integration among participants were the management of complex cases, including impacted or supernumerary teeth, evaluation of bone surrounding the teeth, and the assessment of skeletal discrepancies. These findings are similar to Caiado et al. findings, which indicated CBCT was used for localization of impacted teeth and assessing the amount of root and bone resorption [11]. They also found CBCT very useful in pre-surgical planning, which is similar to our findings that show OT highlighted the critical role of advanced imaging techniques in surgical orthodontic planning where evaluations of bone condition and precise measurements are crucial [11]. Similarly, Kapila and Nervina [19] and Tyndall and Rathore [20] highlighted CBCT superiority to 2D radiographs in bone assessment. Additionally, another study found 3D visualization is essential for surgical planning in cases with significant anatomical variation [21]. Moreover, the participants in our study valued CBCT for its ability to assess bone conditions, such as bone loss or the proximity of teeth to the alveolar bone. Similarly, Yu et al. showed that CBCT scans provide more accurate tracking of bone resorption in patients undergoing orthodontic treatment compared to conventional radiographs [22]. Thus, this integration also appears to enhance the practitioners perceived ability to treat more complex cases, particularly among general practitioners using CATs. This result aligns with the finding stated by a previous study, which indicated an increase in the ability to treat complex endodontic cases when CBCT is used [23]. On the other hand, Woelber et al. found no increase in treatment abilities in complex periodontal cases [24].

Comparison of CBCT integration among more and less experienced clinicians

The above-mentioned integration is reported to be mostly adopted by clinicians with prior experience using advanced imaging and those with more years of practice. Clinicians with over a decade of experience are significantly more likely to incorporate CBCT into their diagnostic and treatment planning processes, as familiarity with advanced imaging technology and confidence in managing complex cases tend to increase with time [4].

In the study, the average years of experience among orthodontists using the CBCT integration tool was 17 years. This may suggest that experienced practitioners, possibly due to increased exposure to 3D technologies and greater confidence in managing complex cases, are more inclined to utilize CBCT to capitalize on its ability to visualise orthogonal plans for a perceived enhanced treatment planning. This result contradicts what was found by Cojocaru et al., who found that dentists who recently graduated dental school and those with less than 5 years of experience tend to use CBCT more often than experienced ones [25]. Furthermore, prior experience with CBCT scans strongly predicts its use in conjunction with treatment planning software, suggesting that familiarity with the technology reduces hesitation to adopt it for orthodontic planning [1,11]. Similar findings from previous studies also highlight that orthodontic postgraduate training plays a pivotal role in accepting and integrating advanced imaging technologies within the orthodontic practice. Hol et al. found that CBCT scans are more frequently requested by specialists than GPs in Norwegian dental clinics [17]. Although a comparison between years of experience in orthodontic practice and CBCT recommendations

was not feasible in the present study, the mean clinical experience of survey respondents (17 ± 10.7 years) indicates that the respondents were experienced dental clinicians.

Effects of CBCT incorporation on clinician communication with patients

While the diagnostic insights provided by CBCT can lead to adjustments in treatment plans, many participants do not believe its integration will significantly improve patient communication, as its benefits appear more clinician-centered, focusing on diagnostic precision. When asked if the new integration would enhance communication with their patients, the majority of participants agreed, while some remained neutral, and a few of them appeared to disagree with the potential improvement. CBCT has been used as a communication tool to enhance patient understanding of treatment, potentially improving their visualization and understanding. If a CBCT prescription is required and correctly justified [26], based on the case complexity, its use can be incorporated beyond treatment planning [27].

Barriers to adopting CBCT incorporation

Despite the numerous advantages, some barriers to patient care regarding using CBCT integration into CAT software were identified, including the high cost of 3D scans and exposure to ionizing radiation. Most GPs and OTs that participated in our study emphasized no significant drawbacks to using CBCT for clinical purposes, and some OT expressed concern about the high cost of purchasing CBCT devices, a concern also identified by Kapila and Nervina [19], which could represent a critical limitation to its broader implementation [7]. Regarding the radiation exposure barrier, although the radiation dose from CBCT is considerably lower than that from conventional CT, clinicians remain cautious about the cumulative effects of ionizing radiation exposure on patients, as noted by Ludlow et al. [21]. These challenges highlight the need for more cost-effective CBCT solutions and continued education on radiation safety to address concerns and reassure both clinicians and patients.

Limitations and future directions

The integration of CBCT with digital orthodontic tools has the potential to greatly improve diagnostic and treatment planning accuracy. However, the adoption of advanced imaging remains limited by concerns about ionizing radiation exposure in children and young adults and its associated costs [28]. Advances in technology, such as low-dose CBCT systems with improved radiation safety, may help address these challenges [26,29]. Previous studies on advanced imaging in orthodontics highlight the need to balance the benefits against the potential and unknown risks of ionizing radiation [30,31]. Additionally, the increase in incidental findings and the reporting requirements for CBCT volumes cannot be ignored, as the acquiring dentist – whether a specialist or not – has a legal obligation to manage abnormal findings identified on 3D imaging [32,33]. As more evidence-based research becomes available, clinicians may gain greater confidence in incorporating advanced imaging for specific cases.

The small sample size, restricted to certain countries, might limit the external validity and generalizability of the findings. Future research can address this limitation by utilizing a larger sample size, representative of GPs and OT worldwide. The sample size of GPs included in this study it is not representative of the populations investigated, which limits the generalizability of the findings to this professional category. The sample population may have been affected by strategies that increased the response rate, including advertising the research project on social media and reaching out to key stakeholders in each country participating in the study. Additionally, the survey's self-reported nature could introduce recall and social desirability bias, due to the assessment of practices from prior clinical experiences [34] and possibility of survey participants to endorse more favorable responses in order to enhance their own self-presentation is also a possible, respectively [35].

Future research should aim to explore objective measures of CBCT use and outcomes by evaluating actual clinician practices with its integration. Longitudinal studies could be valuable in investigating how the increasing availability of CBCT impacts treatment planning and success rates over time. Further studies should focus on developing better low-dose protocols to minimize radiation exposure while maximizing diagnostic utility. Incorporating patient perspectives on CBCT use, particularly concerns related to radiation, would also be beneficial for better informing clinical decision making, informed consent, and developing effective patient education strategies.

Conclusions

The integration of CBCT into orthodontic planning, particularly with clear aligner therapy like ClinCheck® is perceived as advantageous, especially for complex cases involving impacted teeth, skeletal discrepancies, and craniofacial disorders. Its 3D visualization capabilities to provide detailed 3D visualization of hard and soft tissue profiles may enhance diagnostic accuracy and treatment planning, especially for experienced orthodontists. However, its adoption is limited by concerns over ionizing radiation exposure, costs, radiographic interpretive services, and the perception that it may not be necessary for all patients. While this conclusion, based on a survey, highlights the perception of CBCT improving aligner planning, it should be interpreted cautiously, as the research did not explicitly validate it as a proven fact.

Ethics : This research study was designed and conducted at the Mike Petryk School of Dentistry, with ethics approval from the university of Alberta research ethics board (Pro00132448).

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Authors' contributions: KCH: conceptualization, data curation, formal analysis, funding acquisition, investigation, project administration, writing – original draft; me: data curation, writing – original draft; ME: data curation, writing – original draft; t;NCFF: formal analysis, visualization, writing – original draft, writing – review & editing; JAMM: conceptualization, data curation, funding acquisition, writing – review & editing; MLV: conceptualization, data curation, formal analysis, funding acquisition, writing – review & editing; CPP: conceptualization, formal analysis, funding acquisition, investigation, project administration, writing – review & editing, supervision. All authors read and approved the final manuscript.

Data availability: The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Human ethics and consent to participate: This research study was designed and conducted at the Mike Petryk School of Dentistry, University of Alberta, with ethics approval from the research ethics board under protocal number (Pro00132448)..

Disclosure of interest: The authors declare that they have no competing interest.

Supplementary data

Electronic supplements available on the *International Orthodontics* website (https://doi.org/10.1016/j.ortho.2026.101177).

The STROBE reporting checklist

Checklist for Reporting Of Survey Studies (CROSS)

Survey questionnaire

Supplemental figures

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