



Knowledge, Attitudes, and Practices of Teleorthodontics among Orthodontic Professionals in Yemen: A Cross-Sectional Study

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ABSTRACT

Background: Teleorthodontics has the potential to enhance access to orthodontic care in resource-limited settings. This study evaluated the knowledge, attitudes, and practices (KAP) toward teleorthodontics among orthodontic professionals in Yemen.

Methods: A cross-sectional survey was conducted among 120 orthodontists and orthodontic residents from two master's-degree-granting universities in Yemen (Sana'a University and University of Science and Technology) between January and March 2025. A validated 28-item questionnaire assessed KAP using 3-point (knowledge) and 5-point (attitudes/practices) Likert scales. Parametric tests were used to examine the associations between demographics and KAP scores.

Results: Participants (mean age 33.8±4.5 years; 60.0% female; 66.7% residents) demonstrated high knowledge (mean 2.82/3.0, 94.0%), moderately positive attitudes (mean 3.68/5.0, 73.6%), and moderate practices (mean 3.03/5.0, 60.6%) regarding teleorthodontics. Age was significantly associated with attitudes ($p=0.023$) and practices ($p=0.011$), with clinicians aged 35–42 years showing more favorable responses. No significant associations were found between sex, education level, practice setting, or experience (all $p>0.05$).

Conclusion: Orthodontic professionals in Yemen exhibit strong conceptual acceptance of teleorthodontics; however, practical implementation remains limited, likely due to infrastructure and training constraints. Strengthening digital infrastructure and expanding structured teledentistry training may help translate positive perceptions into consistent clinical practice in resource-constrained settings.

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Introduction

Teledentistry is a subset of telemedicine. It refers to the application of telecommunication technology in dental care. It originated in 1994 when it was adopted by the US military to provide remote advice on oral hygiene and preventive care and enhance communication between

dentists and dental laboratories [1].

Within a decade, orthodontics has been influenced by teledentistry. Initially, the management of minor emergencies via video consultations was considered. This was then expanded into a specialized area known as "teleorthodontics," which refers to the utilization of telecom-



munication platforms to deliver orthodontic services remotely [2]. The COVID-19 pandemic significantly accelerated the adoption of teleorthodontics, which became vital for maintaining continuity of care during the lockdowns [3, 4].

Teleorthodontics, like other telemedicine subsets, primarily employs asynchronous and synchronous modes of telecommunication. Asynchronous modes include store-and-forward, remote monitoring, and artificial intelligence (AI)-assisted monitoring. In contrast, synchronous modes include real-time telecommunications [5]. Teleorthodontics mainly employs various acts, including teleconsultation, teleexpertise, telemonitoring, and teleassistance [2, 6, 7].

The integration of teleorthodontics has the potential to significantly improve patient-related outcomes by enhancing communication between orthodontists and patients, reducing the necessity for in-person visits, and ensuring continuity of care [8, 9].

Given that the use of teleorthodontics relies on the active involvement of orthodontic practitioners, their knowledge, attitudes, and practices (KAP) of teleorthodontics must be evaluated. Although teleorthodontics has proven its significance, few studies have specifically evaluated orthodontists' and orthodontic residents' perceptions of teleorthodontics [10–15]. A recent systematic review demonstrated moderate knowledge and relatively poor practice of teledentistry. The authors recommended conducting well-designed studies to investigate strategies for enhancing dental practitioners' knowledge and practice of teledentistry interventions [9].

Therefore, this study was conducted to evaluate the KAP towards teleorthodontics among orthodontists and orthodontic residents in Yemen. Additionally, the study examined the association between the participants' demographic and professional characteristics (sex, educational level, practice setting, experience, and age) and their KAP.

Subjects and Methods

Study Design

This study was designed as a cross-sectional survey of KAP.

Study Setting

The study was conducted at Sana'a University and the University of Science and Technology in Sana'a, Yemen, between January and March 2025. These institutions were selected because they were the only universities in Yemen licensed to offer a master's program in orthodontics at the time of the study.

Study Participants and Eligibility Criteria

All registered orthodontists at the Faculty of Dentistry of Sana'a University ($n = 152$) and the University of Science and Technology ($n = 58$) during the academic year 2023–2024 were initially considered eligible for the study, thus making the target population 210 individuals. Voluntary consent was necessary for inclusion. Participants

who lived outside Yemen or declined to participate were excluded. These decisions resulted in the exclusion of 48 participants. Forty-two participants were included in the pilot testing and excluded from the final analysis to prevent bias from prior exposure to the questionnaire items. Thus, the study included 120 participants. The STROBE flow diagram was used to explain the participant selection and retention (Figure 1).

Data Collection

Information regarding the participants' demographics, professional characteristics, and KAP toward teleorthodontics was gathered through a structured questionnaire using Google Forms. The questionnaire was compiled based on previous studies [3, 14, 16]. Knowledge and attitude variables were evaluated using ten items, while only eight items were used to measure practice variables. Five experts in orthodontics and healthcare research confirmed the content validity of the questionnaire [17]. Pilot testing ($n = 42$) revealed high internal consistency, indicated by Cronbach's alpha values of 0.83, 0.92, and 0.76 for knowledge, attitudes, and practices, respectively; thus, the reliability was more than 0.7 [18].

To minimize missing responses, the Google Forms survey was set up in such a way that answering was required for each item of the questionnaire. Therefore, it was out of the question for the participants to submit the questionnaire with some item responses missing; therefore, there was no item-level missing data in the final dataset. Only fully completed questionnaires were included in the analysis.

The KAP questionnaire scoring system was based on two Likert-type scales. A 3-point scale was used for knowledge items. The responses were rated as "No" if the average score was under 1.66, "Uncertain" if the score was between 1.66 and less than 2.34 and "Yes" if the score was from 2.34 to 3. Attitudes and practices were measured on 5-point Likert scales and were interpreted based on specific score intervals. For attitudes, a score that was lower than 1.8 represented a "Strongly Disagree" whereas a score between 1.8 and less than 2.6 was "Disagree," a score of 2.6 to less than 3.4 was "Neutral," a score of 3.4 to less than 4.2 was "Agree," and a score of 4.2 to 5 was "Strongly Agree." The same scores were applied to the practices' items with the interpretation of "Never," "Rarely," "Sometimes," "Often," and "Always." The cutoff points were determined by the equal-interval method, which is the standard way to categorize Likert-scale data (for example Pimentel, 2019 [19]).

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). The significance level was set at $p < 0.05$. KAP variables were measured using multi-item Likert scales and analyzed as summed scores. Although individual Likert

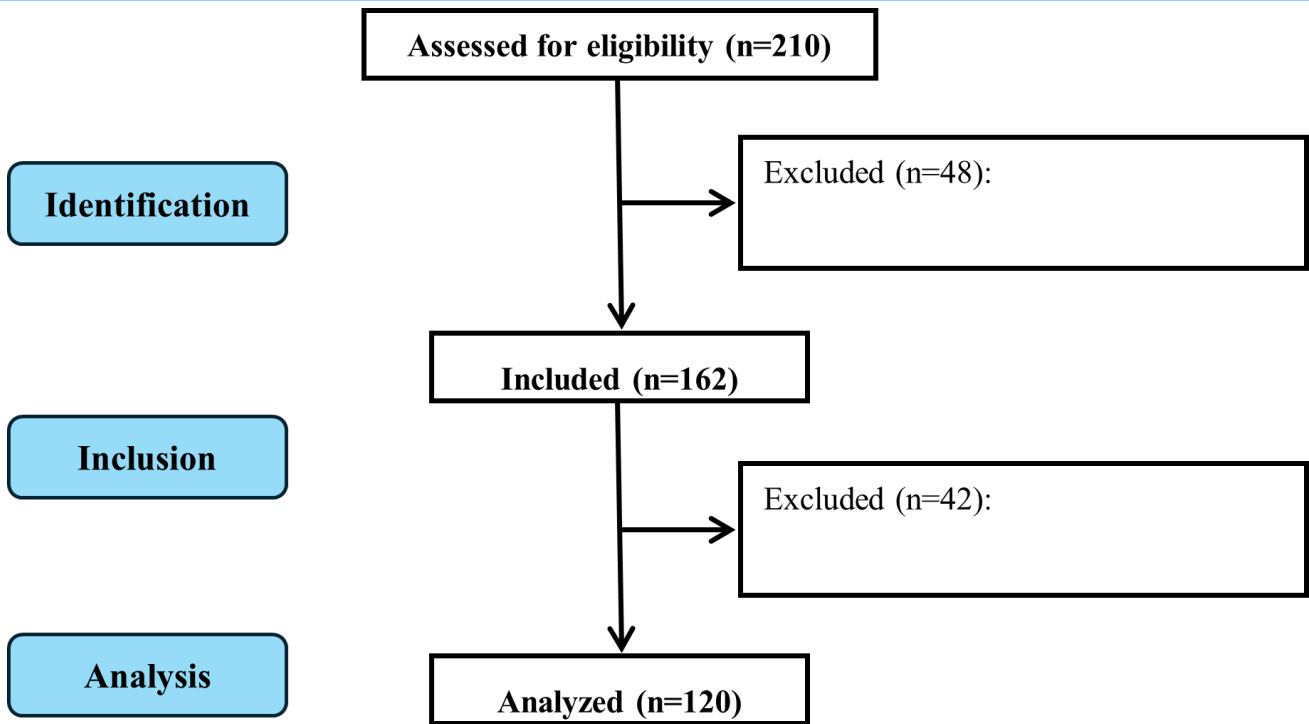


Figure 1. STROB flow diagram showing the participants' selection and retainment process

items are ordinal, aggregated Likert scale scores can be treated as continuous variables when normality assumptions are met [20–22]. Normality of data was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests; knowledge ($K-S = 0.155$, $p = 0.057$; $S-W = 0.808$, $p = 0.053$), attitudes ($K-S = 0.093$, $p = 0.086$; $S-W = 0.948$, $p = 0.071$), and practices ($K-S = 0.075$, $p = 0.200$; $S-W = 0.982$, $p = 0.342$) all showed $p > 0.05$, indicating normal distribution and supporting the use of parametric tests (independent-samples t-test and one-way ANOVA). Descriptive statistics (frequency, percent, mean, standard deviation (SD), and relative importance index (RII)) were used to summarize demographic data and KAP variables. The RII was used to determine the relative standing of KAP-related items and the overall average [23, 24]. The RII transforms respondents' Likert-scale ratings into a standardized score between 0 and 1, calculated as

$$RII = \frac{\sum W}{AN}$$

Where:

w = Weight assigned to each factor (1, 2, 3, 4, 5 based on the Likert scale)

A = Highest possible weight

N = Total number of respondents

Interpretation of RII values

- RII = 1 → Factor is of highest importance.
- RII close to 0 → Factor is of least importance

This method allows for the ranking of items based on respondents' perceptions and facilitates comparisons across multiple questionnaire items. Although not commonly used in orthodontic research, the RII is widely applied in survey-based research to prioritize subjective

responses and provide clear interpretability of data.

Ethical Approval

This study was approved by the Medical Ethics Committee of the Faculty of Dentistry, Sana'a University (No. 1029). The Google Forms survey began with an introductory page outlining the study's objectives and procedures. It clearly stated that participation was voluntary, responses would be kept confidential, and participants could withdraw at any time without consequences. Participants were also informed that their completion and submission of the questionnaire would be considered as providing informed consent to participate in the study.

Results

Respondents' Characteristics

A total of 120 individuals participated in the study, with a mean (SD) age of 33.8 (4.5) years. They were predominantly female (60.0%) and orthodontic residents (66.7%). The majority were employed in private practice settings (75.0%) and had between one and four years of clinical experience (71.25%). In terms of age distribution, 60% of the participants were in the 27–34-year age group (Table 1).

Perceived knowledge about teleorthodontics

The results regarding respondents' perceived knowledge of teleorthodontics are presented in Table (2). The (KN3) item (Teleorthodontics involves the use of information technology and telecommunication to diagnose cases and provide consultations and treatments in this field) obtained the highest ranking in terms of the respondents' knowledge of teleorthodontics, with a mean (SD) of 2.94 (0.269) and an RII of 98.0%. In contrast, the (KN8) item (Teleorthodontics platforms benefit specialists and residents in busy and densely populated work locations.)



Table[1]: Demographic and professional characteristics of study participants (N = 120)

Characteristic		N	Percent (%)
Sex	Female	72	60.0
	Male	48	40.0
Educational Level	Master's degree	40	33.3
	Resident	80	66.7
Practice Setting	Private sector	85	75.0
	Public sector	20	15.0
	Both sectors	15	10.0
Experience (Yrs.)	From 1 to 4	84	71.25
	From 5 to 8	27	21.75
	From 9 to 12	9	7.5
Age Group (Yrs.)	From 27 to 34	72	60.0
	From 35 to 42	39	32.5
	From 43 to 50	9	7.5

The dimension was ranked the lowest in terms of the respondents' knowledge about teleorthodontics, with a mean (SD) of 2.60 (0.653) and an RII of 86.7%. Overall, respondents' knowledge scored high, with a mean (SD) of 2.82 (.258) and an RII of 94%.

Attitudes about teleorthodontics

The results regarding respondents' attitudes towards teleorthodontics are presented in Table (3). The (AT2) item (Teleorthodontics platforms greatly assist orthodontists in treating their daily cases, especially complex cases.) The highest ranking item was I believe that teleorthodontics will improve the quality towards orthodontic treatment with a mean (SD) of 3.97 (0.835) and an RII of 79.4%. In contrast, the (AT7) item (Teleorthodontics platforms reduce the costs of orthodontic treatment for patients.) was ranked lowest in terms of the respondents' attitude towards teleorthodontics, with a mean (SD) of 3.12 (1.017) and an RII of 62.4%. Overall, respondents' attitude scored high, with a mean (SD) of 3.68 (0.728) and an RII of 73.6% (Agree).

Practices of teleorthodontics

The results regarding the respondents' teleorthodontic practices are presented in Table (4). The (PR4) item (I benefit from the Internet to access educational websites related to orthodontics.) obtained the highest ranking in terms of the respondents' practice of teleorthodontics, with a mean (SD) of 4.17 (0.803) and an RII of 83.4%. In contrast, the (PR1) item (Free internet is available at my workplace) was ranked lowest in terms of the respondents' practice of teleorthodontics, with a mean (SD) of 2.43 (1.301) and an RII of 48.6%. Overall, respondents' practice scored moderate, with a mean (SD) of 3.03 (0.732) and an RII of 60.6% (Sometimes).

Association between KAP and participants' characteristics

The association between KAP and participants' characteristics, as well as the magnitude of differences between

groups, were assessed using effect size measures (Cohen's d for t-tests and Eta-squared (η^2) for ANOVA tests), with results presented in Table (5).

Across most demographic categories (sex, educational level, practice setting, and experience), no statistically significant differences were found in the participants' KAP regarding teleorthodontics (all p-values > 0.05). However, age was significantly associated with both attitudes (p = 0.023) and practices (p = 0.013). Among the non-significant findings, the effect sizes were uniformly small or negligible. For sex, Cohen's d values ranged from 0.15 to 0.29, indicating minimal practical differences between male and female participants. Educational level had even smaller effects (d = 0.02-0.15), indicating that the type of degree does not cause any meaningful variation. The effect sizes of the practice setting and years of experience were also small (η^2 = 0.01, 0.04); thus, these variables produced little variance in the KAP scores.

Medium effect sizes were obtained for the age group differences, in which the results were statistically significant: the age of the respondents accounted for 6% of the variance in attitudes (η^2 = 0.06) and 7% of the variance in practices (η^2 = 0.07). These values, based on Cohen's (1988) criteria [25], indicate the presence of effects that are not merely statistically significant but of moderate practical importance.

After one-way ANOVA showed significant effects of age, a Tukey Honestly Significant Difference (HSD) post-hoc test was performed to explore which specific pairs of groups differed in attitudes and practices. The results are presented in Table (6).

The only significant differences were between the youngest group (27-34 years) and the middle group (35-42 years). The middle-aged group (35–42 years) had significantly higher attitude scores than the younger 27-34 group (p = 0.034, 95% CI [-0.69, -0.02]). The same was true for behaviors in that the 35, 42 group scored

Table[2]: Descriptive statistics of respondents' perceived knowledge

Rank	No.	Item	Mean	SD	RII	Label
1	KN3	Teleorthodontics involves the use of information technology and telecommunication to diagnose cases and provide consultations and treatments in this field.	2.94	.269	98.0%	Yes
2	KN1	Do you know what teleorthodontics?	2.93	.250	97.7%	Yes
3	KN10	Teleorthodontics platforms can be utilized to gain diverse knowledge in fixed, removable, functional, clear aligner, and other types of orthodontics.	2.92	.347	97.3%	Yes
4	KN2	Do you have knowledge about teleconsultations in orthodontics?	2.89	.384	96.3%	Yes
5	KN9	Teleorthodontics platforms benefit residents in remote areas.	2.89	.384	96.3%	Yes
6	KN5	Do teleorthodontics platforms facilitate access to expert consultations for complex orthodontic case?	2.85	.423	95.0%	Yes
7	KN7	Teleorthodontics platforms enhance and support the traditional orthodontic treatment provided by orthodontists in their practices.	2.81	.490	93.7%	Yes
8	KN6	Teleorthodontics platforms help save time, effort, and reduce costs when treating orthodontic cases.	2.72	.579	90.7%	Yes
9	KN4	Does teleorthodontics platform assist in monitoring and evaluating orthodontic cases?	2.66	.615	88.7%	Yes
10	KN8	Teleorthodontics platforms benefit specialists and residents in busy and densely populated work locations.	2.60	.653	86.7%	Yes
Knowledge			2.82	.258	94.0%	Yes

Table[3]: Descriptive statistics of respondents' attitudes

Rank	No.	Item	Mean	SD	RII	Label
1	AT2	Teleorthodontics platforms greatly assist orthodontists in treating their daily cases, especially complex ones.	3.97	.835	79.4%	Agree
2	AT1	Teleorthodontics is very beneficial.	3.92	.890	78.4%	Agree
3	AT5	Teleorthodontic platforms facilitate practitioners in monitoring their orthodontic cases.	3.85	.857	77.0%	Agree
4	AT3	Teleorthodontics is beneficial in improving access to high-quality orthodontic care.	3.83	.892	76.6%	Agree
5	AT8	Teleorthodontic platforms help monitor the cases I follow in my practice.	3.77	.83	75.4%	Agree
6	AT10	Orthodontic teleconsultations through platforms are accurate and substitute traditional consultations in the workplace.	3.77	.968	75.4%	Neutral
7	AT6	Teleorthodontic platforms save time and effort in orthodontic treatments.	3.74	.992	74.8%	Agree
8	AT4	Teleorthodontics platforms answer all my inquiries regarding the cases I follow in my practice.	3.50	1.077	70.0%	Agree
9	AT9	Teleorthodontic platforms are a good and useful tool for acquiring skills and knowledge in orthodontics.	3.30	1.149	66.0%	Neutral
10	AT7	Teleorthodontics platforms reduce the costs of orthodontic treatment for patients.	3.12	1.017	62.4%	Neutral
Attitudes			3.68	.728	73.6%	Agree

higher than the 27-34 group ($p = 0.008$, 95% CI [-0.76, -0.09]).

No other pairwise comparisons were statistically significant. The oldest group (43-47 years) did not show significant differences in attitudes or practices compared to the 27-34 or 35-42 groups in attitudes or practices. Although this group had the highest average scores, the small sample size ($n=9$) is probably the reason the differences

did not reach statistical significance.

Discussion

Our study participants reported a very good level of knowledge about teleorthodontics, with an average score of 2.82/3.0 and an RII of 94%. This is in line with what has been found among orthodontic specialists in other countries, such as India [10, 11, 14, 26], the United States, Asia, Australia, and Europe [12, 13]. In con-



Table[4]: Descriptive statistics of respondents' practices

Rank	No.	Item	Mean	SD	RII	Label
1	PR4	I benefit from the internet to access educational web-sites related to orthodontics.	4.17	.803	83.4%	Often
2	PR2	Internet is available at my home or place of residence.	4.05	1.029	81.0%	Often
3	PR3	I use social media for consultations related to orthodontics.	3.12	1.017	62.4%	Sometimes
4	PR8	I use orthodontics platforms in various areas of orthodontics, including fixed, removable, functional, clear aligners, and others.	2.73	1.200	54.6%	Sometimes
5	PR5	I use remote orthodontics platforms in my practice to diagnose orthodontic cases.	2.64	1.098	52.8%	Sometimes
6	PR6	I use teleorthodontics platforms in my practice to treat and develop treatment plans for my orthodontic cases.	2.62	1.108	52.4%	Sometimes
7	PR7	I use teleorthodontics platforms in my practice to monitor and follow up on my orthodontic cases.	2.49	1.092	49.8%	Rarely
8	PR1	Free internet is available at my workplace.	2.43	1.301	48.6%	Rarely
Practices			3.03	.732	60.6%	Sometimes

trast, general dentists in countries such as Turkey [27], Saudi Arabia [15], and Malaysia [9] are less familiar with teledentistry, probably due to their different training and the focus of their work. We attribute the high level of knowledge of our participants to their specialization or possibly self-learning. Nonetheless, even at the same time of high knowledge, there is limited continuing education infrastructure in Yemen [28], implying that the local orthodontists would be depending on the international articles and online resources for their knowledge of teleorthodontics. In brief, the present study demonstrated that orthodontic professionals in Yemen have uniformly high knowledge levels, which are most probably the result of informal or self-directed learning rather than formal institutional education.

On average, the participants held moderately positive attitudes towards teleorthodontics (mean 3.68, 73.6% agreement). Such a level of enthusiasm can also be seen in other international studies [3, 4, 9–11, 14, 26, 29–32]. For example, most Indian orthodontists felt that teledentistry could save time and increase patient access [14]. However, in our study, the statement that teleorthodontics leads to patient treatment cost savings got the least number of agreements (RII 62.4%), which might be due to the fact that the high internet and device costs in Yemen undermine this expected advantage.

Regarding the teleorthodontics practices of participants, the actual use of teleorthodontic platforms was only moderate (mean 3.03, 60.6% RII). The most frequent practice was using the Internet to access educational sites (PR4), and the Internet at home was widely available (PR2), reflecting general Internet engagement. However, the lowest-scoring item was "Free internet at my workplace" (RII 48.6%, rated "Rarely"), highlighting a major barrier. In practice, few respondents regularly used teleorthodontics for diagnosing or monitoring cases (most items only "Sometimes" or "Rarely"). This pattern aligns with re-

ports from other countries, such as the United States [33] and India [26]. However, Saudi [15] and Malaysian [9] orthodontists showed lower teleorthodontics practice levels. In Yemen, bridging the knowledge/attitude and practice gap is probably due to infrastructure and resource limitations. Unstable or costly Internet, lack of equipment, and little institutional support all contribute to the difficulty of teleorthodontic work.

Our study did not reveal any significant sex differences in knowledge of teleorthodontics, and no differences emerged across age, qualification, practice type, or experience. Our results mirror those of Prasadhati et al. [29], who also found no demographic-based differences. Similarly, Kulkarni and Goyal [10] reported no age-related differences, although males showed slightly higher knowledge ($p = 0.042$). In contrast, George et al. [14] found that younger orthodontists (25-35 years) and those combining academic and clinical roles were more knowledgeable, while Ashwanthi et al. [11] and Mengi et al. [26] observed higher levels of knowledge in females, residents, and academicians.

Moreover, we found no significant differences between male and female orthodontic professionals in attitudes towards tele-orthodontics, nor did we find any differences when looking at educational level, practice setting, or experience, thereby indicating that these variables were not experiential influences on tele-orthodontics attitudes. Our findings are consistent with those of Prasadhati et al. [29], who performed the same analyses and obtained similar results; they also reported no attitude differences based on the same variables. Kulakrni and Goyal [10] also found no significant sex differences in attitudes toward teaching. Ashwanthi et al. [11], on the other hand, reported no effect of sex or education, but those who had been practising for 4-12 years displayed higher awareness ($p < 0.0001$).

One notable difference we discovered was a significant

Table[5]: Differences in participants' KAP according to participants' characteristics

KAP variable	Characteristic	Group	N	Mean \pm SD	p-value	Effect Size	95% CI
Knowledge	Sex ^a	Female	72	2.80 \pm 0.27	0.258	d = 0.20 (Small)	-0.145, 0.039
		Male	48	2.85 \pm 0.39			
	Education ^a	Master's	40	2.80 \pm 0.26	0.417	d = 0.15 (Negligible)	-0.059, 0.142
		Resident	80	2.84 \pm 0.26			
	Practice Setting ^b	Private	85	2.84 \pm 0.24	0.413	$\eta^2 = 0.015$ (Small)	2.67, 2.91
		Public	20	2.77 \pm 0.34			
		Both	15	2.79 \pm 0.22			
	Experience (Yrs.) ^b	1-4	84	2.81 \pm 0.25	0.085	$\eta^2 = 0.041$ (Small)	2.34, 3.06
		5-8	27	2.90 \pm 0.15			
		9-12	9	2.70 \pm 0.47			
	Age Group (Yrs.) ^b	27-34	72	2.80 \pm 0.27	0.360	$\eta^2 = 0.017$ (Small)	2.73, 2.87
		35-42	39	2.87 \pm 0.25			
43-47		9	2.83 \pm 0.25				
Attitudes	Sex ^a	Female	72	3.62 \pm 0.65	0.287	d = 0.21 (Small)	-0.436, 0.131
		Male	48	3.77 \pm 0.83			
	Education ^a	Master's	40	3.65 \pm 0.84	0.775	d = 0.05 (Negligible)	-0.260, 0.348
		Resident	80	3.69 \pm 0.67			
	Practice Setting ^b	Private	85	3.71 \pm 0.75	0.437	$\eta^2 = 0.014$ (Small)	3.22, 3.68
		Public	20	3.74 \pm 0.81			
		Both	15	3.45 \pm 0.42			
	Experience (Yrs.) ^b	1-4	84	3.66 \pm 0.74	0.312	$\eta^2 = 0.019$ (Small)	2.65, 4.15
		5-8	27	3.82 \pm 0.58			
		9-12	9	3.40 \pm 0.98			
	Age Group (Yrs.) ^b	27-34	72	3.53 \pm 0.73	0.023*	$\eta^2 = 0.062$ (Medium)	3.36, 3.70
		35-42	39	3.89 \pm 0.73			
43-47		9	3.94 \pm 0.48				
Practices	Sex ^a	Female	72	2.94 \pm 0.69	0.132	d = 0.29 (Small)	-0.489, 0.065
		Male	48	3.16 \pm 0.79			
	Education ^a	Master's	40	3.02 \pm 0.63	0.915	d = 0.02 (Negligible)	-0.338, 0.304
		Resident	80	3.04 \pm 0.91			
	Practice Setting ^b	Private	85	3.09 \pm 0.71	0.134	$\eta^2 = 0.019$ (Small)	2.47, 3.23
		Public	20	2.89 \pm 0.86			
		Both	15	2.85 \pm 0.68			
	Experience (Yrs.) ^b	1-4	84	2.95 \pm 0.71	0.227	$\eta^2 = 0.025$ (Small)	2.63, 3.85
		5-8	27	3.19 \pm 0.78			
		9-12	9	3.24 \pm 0.79			
	Age Group (Yrs.) ^b	27-34	72	2.87 \pm 0.72	0.011*	$\eta^2 = 0.075$ (Medium)	2.78, 3.12
		35-42	39	3.30 \pm 0.73			
43-47		9	3.14 \pm 0.46				

* Statistically Significant at p<0.05.

a Independent-Samples T-Test (Effect Size: Cohen's d)

b One-Way ANOVA Test (Effect Size: Eta-squared, η^2)

CI = Confidence Interval for the Mean (Lower Bound – Upper Bound)



Table[6]: Multiple comparisons (Tukey HSD) among age groups for attitudes and practices

(I) Age Group	(J) Age Group	Attitudes				Practices			
		Mean Difference (I-J)	Std. Error	p-value	95% CI	Mean Difference (I-J)	Std. Error	p-value	95% CI
27-34	35-42	-0.358*	0.141	0.034	-0.69, -0.02	-0.428*	0.141	0.008	-0.76, -0.09
	43-47	-0.413	0.252	0.233	-1.01, 0.18	-0.269	0.251	0.534	-0.87, 0.33
35-42	27-34	0.358*	0.141	0.034	0.02, 0.69	0.428*	0.141	0.008	0.09, 0.76
	43-47	-0.055	0.263	0.976	-0.68, 0.57	0.159	0.262	0.817	-0.46, 0.78
43-47	27-34	0.413	0.252	0.233	-0.18, 1.01	0.269	0.251	0.534	-0.33, 0.87
	35-42	0.055	0.263	0.976	-0.57, 0.68	-0.159	0.262	0.817	-0.78, 0.46

* Statistically Significant at $p < 0.05$.

age effect: clinicians aged 35-42 years reported significantly more positive attitudes than those aged 27-34 ($p=0.034$). This finding contrasts with some studies in which younger dentists showed a more positive attitude towards teledentistry [14]. A possible interpretation of this finding in the Yemeni context is that mid-career orthodontists who have experienced the difficulties of the health system during the war probably appreciate any tool that enhances efficiency and patient follow-up. They might be in positions where they coordinate care or communicate with specialists abroad, thus making teleorthodontics more relevant to them at present. In short, the overall attitude of the clinicians was moderately positive, but conditioned by the realities of a war-torn country, they appreciated the benefits of teleorthodontics while still being quite aware of the limitations that Yemen has. Moreover, our results demonstrated that teleorthodontics practice was similar regardless of the sex, educational level, practice setting, or experience of the practitioner, which means that these clinical application factors were not influenced by the abovementioned factors. These results are consistent with those of Kulakrni and Goyal [10], who found no differences between males and females. In contrast, Ashwanthi et al. [11] found that orthodontists and clinicians with 8 and 12 years of experience had a higher level of practice ($p < 0.0001$), but the difference was not related to sex ($p = 0.141$). Likewise, Prasadhati et al. [29] identified that those with over five years of experience were the greater users ($p = 0.005$).

It is worth mentioning that the 35-42 age group was the one that, once again, indicated significantly higher practice levels than the 27-34 group ($p=0.008$). Perhaps, these mid-career orthodontists have more established clinics or greater autonomy in deciding what tools to use, while younger clinicians, even if they are tech-savvy, may lack the opportunities or resources to implement teleorthodontics. Thus, this result reveals that in Yemen, the real telehealth adoption requires not just the willingness but going hand in hand with a stable practice environment.

In our situation, the difficult environment in Yemen seems

to erase the differences in many demographics: all practitioners are facing the same systemic obstacles and educational gaps, irrespective of their background. Age was the only exception: the moderate effect sizes ($\eta^2 = 0.06, 0.07$) for attitudes and practices indicate that only 6% and 7% of the variance can be accounted for by age group. In summary, age/experience seems to influence orthodontists' engagement with teleorthodontics in Yemen, which may be the result of differences in role or perspective, as argued above.

Many of the results obtained are likely due to the influence of the local environment. The healthcare system in Yemen has been greatly affected by prolonged armed conflict and a lack of funding. According to reports, it still suffers from "a healthcare infrastructure that is less than adequate, financial resources being very limited, and great difficulties in accessibility" [34, 35].

Even before the war, more than half of the population did not have access to basic healthcare, and government expenditure on health was as little as 1.3% of the GDP, according to the WHO [34]. Such deeply ingrained problems have set the stage for a situation where teleorthodontics, as an example, could be very useful, at least theoretically, but the actual implementation is still far from easy.

Yemen's telecommunications network is extremely fragile: only approximately 27% of the population has access to the internet, the connection speed is very slow (often lower than 1 Mbps), and the price is exorbitantly high (more than \$15 per GB) [28]. Electricity is also quite unstable, and there are areas where residents experience blackouts daily [28, 36]. Hence, one can imagine that an orthodontist who is even quite determined will find it very difficult to use video calls or online platform options for consultations on a regular basis. The important elements of this situation include:

- Connectivity weaknesses: The coverage of mobile and fixed broadband is limited [28]; therefore, it is very likely that a remote consultation cannot be conducted or that the patient will become very frustrated when attempting to do so. The fact that not many offices

offered free Internet clarified this lack.

- Cost and power: Owing to the high telecommunication costs and frequent power cuts [28, 36], it is difficult to coordinate different parties for teleorthodontics sessions.
- Education and assistance: The trend in Yemen is that healthcare personnel are untrained for a long time [28]. Therefore, orthodontists do not have the opportunity to attend seminars or telehealth-related courses; they basically acquire their knowledge from exposure to telehealth. This may be the reason why knowledge is high (through self-learning), but there is a shortage of official practice guidelines.
- Average patient distance from the nearest health service point: According to the report, almost one-third of the people in Yemen have to walk for more than 30 minutes to get to the nearest healthcare facility, and there are also cases where people spend more than one hour on the road [37]. Teleorthodontics could, in principle, help this situation, but it would work only if the problems related to the infrastructure were addressed.
- The health sector is under the shadow of the conflict: Because of the war, some medical facilities have been destroyed and lack basic equipment and staff [34]. The ones that are still functioning have become overcrowded and have a scarcity of personnel, which makes these doctors and nurses refrain from embracing new systems unless they are fully supported."

Yemen's extraordinary difficulties, such as war, poverty, and poor internet, have, in part, grounded our findings. This may result in relatively modest practice levels, even when knowledge and attitudes are high. From our study, it appears that fixing the infrastructure (improving internet access, providing subsidies, and providing reliable power) as well as putting a professional training effort into teledentistry might be the two first steps toward teleorthodontics becoming a reality in Yemen. Being a cross-sectional study, this study is based on self-reported data, which might come with some bias (e.g., knowledge and attitudes could have been overestimated). In addition, the sample consisted only of orthodontists and residents in Yemen; therefore, the results might not apply to other places. In addition, we did not consider the guessing skills of digital devices or the help one gets for telehealth from the institution, both of which may be linked to a better understanding of the KAP differences. On balance, however, our study offers an elaborate picture of teleorthodontics in a difficult environment, thereby highlighting the potential and challenges of remote care in Yemen.

Conclusion

Orthodontic professionals in Yemen are knowledgeable about and have moderately positive attitudes towards

teleorthodontics. However, the overall clinical practice was only moderate, suggesting that orthodontists have not yet fully applied their knowledge in practice. The difference between knowledge and implementation is apparently due to external environmental factors, such as unstable internet, high costs of connectivity, unreliable electricity, lack of institutional support, and inadequate structured training, rather than professional readiness. Most demographic variables had no significant differences except age: clinicians who were 35-42 years old tended to have the most positive attitudes and the highest practice levels. The results still tend to imply that teleorthodontic practice in Yemen is probably more dependent on clinicians' professional stability and clinical autonomy than on their familiarity with technology being a generation thing. There is no doubt that digital infrastructure should be fortified and structured training in teledentistry should be increased to facilitate a higher level of practical integration. Researchers can also consider using longitudinal designs in future investigations and look into digital literacy and institutional readiness as factors that would, among others, enable sustainable implementation in resource-limited areas.

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