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Unintended Errors in Orthodontic Clinical Practice: A Cross-sectional Survey

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Abstract

Background: The use of fixed orthodontic appliance is usually accompanied with complex mechanotherapy involving several steps. The complex processes involve band placement, bonding of orthodontic brackets, archwire selection and ligation amongst others. This study aims to estimate the incidence and the causes of unintended errors during fixed orthodontic treatment among orthodontic practitioners.

Methods: This study was an electronic questionnaire-based survey conducted among 53 orthodontics practitioners. Data was collected over a 7-month period (September, 2022 to March, 2023). Simple descriptive analysis of the data was done on Statistical Package for the Social Sciences (SPSS) version 22.

Results: Wrong bracket positioning 53 (100%), missed bracket ligation 51 (96.2%) and non-placement of bend-backs (when indicated) 51 (96.2%) were the errors mostly reported by the respondents while the least reported errors were: placement of bend-back when not indicated 23 (43.4%), unintentional use of wrong archwire materials 28 (52.8%) and swapping archwires between the arches, 28 (52.8%). Majority of the participants were of the opinion that stressful working environment (67.9%), inadequate materials (52.8%) and shortage of manpower (35.8%) were responsible for the mistakes commonly encountered. Majority of the participants also agreed that orthodontic checklist would help to reduce the incidence [30 (56.6%)] of the unintended errors and were willing to apply [35(66.0)] the orthodontic checklist in their practices.

Conclusion: Wrong bracket position was the most occurring error among the participants and majority of the participants agreed that orthodontic checklist would reduce the incidence of the errors. Therefore, there is the need to develop a workable orthodontic checklist.

Keywords: Clinical practice, Orthodontics, Unintended errors

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ORIGINAL ARTICLE

Introduction

Orthodontic treatment involves the placement of removable or fixed appliances for the purpose of the desired tooth movement. The placement of fixed appliance involves several steps and requires the application of appropriate mechanotherapy to bring about expected treatment outcome. These steps involve but not limited to: molar bands cementation, bonding of orthodontic brackets, ligation of archwires within the bracket slot and the application of auxillaries like power chain and elastics.

Andrew recommended that orthodontic brackets should be accurately positioned midway mesio-distally on the clinical crown and along the facial axis of the clinical crown.[1] Accurate bracket positioning is a pre-requisite for ideal orthodontic detailing and finishing because it brings about three-dimensional tooth positioning that is in-built in the various bracket prescriptions.[2] Errors in bracket positioning between clinicians and even by the same clinician when bonding in various areas of the mouth have been reported.[2,3,4] making ideal tooth positioning difficult if not impossible.[5] Also, Kravit & Miller noted reversal in bracket prescription torque when there is an inversion of orthodontic brackets.[6] It is therefore important to note that proper bracket positioning

amongst other biomechanics, contributes to improved smile aesthetic, functionality and stability of the treatment.[7]

Orthodontic archwires are used to deliver optimal force required to bring about desired tooth movement without causing damage to the periodontium.[8] There is a wide range of archwires available in clinical practice and the choice of archwire at a particular stage of treatment is key to achieving expected outcome. The choice of arch wire material, dimension and form (whether upper or lower jaw) should be intended to achieve a specific purpose during treatment. Archwires are specific for each jaw especially with regard to the inter-canine and inter-molar widths; and when chosen rightly, it contributes to improved stability.[9] Clinicians may find themselves making the wrong choices especially when they have limited knowledge on the mechanical property and the application of orthodontic archwires. Additionally, the use of wrong archwire may be an oversight due not stress.

The ligation of orthodontic archwires within the bracket slot can be achieved either by elastomeric module, stainless steel ligation or the more recently developed self-ligating bracket.[10] Ligation tends to have a direct effect on the biomechanics through the friction between the archwire and the bracket slot. The friction generated between the wire-bracket interfaces is particularly useful during the leveling and alignment phase of treatment. In order to maximize the springiness of the superelastic wire and reduce treatment time, all bonded teeth are usually ligated. When a bracket is missed during ligation, the tooth is cut-off from the entire biomechanics, which could lead to prolonged treatment time.

Sometimes the orthodontists may modify the treatment protocol by incorporating bend-backs which help to reinforce anchorage by preventing flaring of the anterior teeth. In addition, the choice of elastic gauge, power chain for space closure and placement of molar band are also important considerations.

When clinicians, out of omission fail to adhere strictly to treatment protocol, poor aesthetic and unstable outcome will inevitably occur. In several scenarios, there will be unwanted tooth movement, undue discomfort to the patient, prolong treatment time and ultimately poor treatment finishing.[11]

In order to reduce the incidence of these errors, the use of checklist could serve as a vital tool. Checklist is an organized tool that simplifies conceptualization and recall of information which leads to improved clinical performance and error prevention.[12] Orthodontic checklist could be applied before, during and post orthodontic treatment. Applying the checklist during treatment especially at initial set-up and follow-up visits will help improve treatment outcome. Several contributing factors such as inadequate supervision, non-availability of materials and stressful working conditions amongst others will be evaluated in this study as possible causes of the errors encountered in practice. The incidence of these errors appear to be scarcely reported in the literature.

The aim of this survey was to estimate the incidence and the causes of these unintended errors during fixed orthodontic treatment among orthodontics practitioners in Nigeria. The authors also discussed the clinical importance of adhering to standard protocols and the need for checklist in order to minimize the occurrences of these errors. The rationale of the study was to ensure that orthodontists manage their patients with very minimal errors.

Materials and Methods

Ethical approval was obtained from the research and ethics committee of the Edo State Hospital Management Agency (A732/T/5). This cross-sectional descriptive study was an electronic questionnaire-based survey conducted among consultant orthodontists, certified orthodontic practitioners and post-graduate students undergoing training as residents in the specialty. Confidentiality was ensured as the request to participate was sent via the Nigeria Association of Orthodontist WhatsApp platform and respondents were not required to give personal information specific to themselves like names and specific centre of practice in the survey tool. Only orthodontists practicing in Nigeria and post-graduate orthodontist residents receiving training in Nigeria participated in the survey. Orthodontists who are not in active clinical practice or practice outside the shore of Nigeria were excluded from the study. Participants were recruited using the volunteer (opt-in) sampling panel. Participants volunteered themselves to willingly participate in the survey. Data was collected over a period of 7-months (September, 2022 to March, 2023) through an online self-administer questionnaire designed in Google form and shared on

the WhatsApp platform of the Nigeria Association of Orthodontists. A total of 53 participants filled the online questionnaire, which accounted for a 75.7% response rate. The participants who completed the survey include: 20 post-graduate students (4 registrars, 16 senior registrars), 2 certified orthodontic practitioners and 31 consultant orthodontists.

Surveying Tool

The questionnaire used in this study was in 4 sections. Demographic information like age group, gender, location of practice, designation and duration of practice were part of the first section of the questionnaire. The second section of the questionnaire comprised of eleven questions centered on errors encounter in the orthodontic clinic and participants were to tick an option from a 5-point Likert scale of frequency (Never-Rarely-Sometimes-Often-Always). The third part included causes of the errors encountered by the respondents and they were asked to tick as many options as possible among the seven possible causes provided. The importance and willingness of the clinicians to utilize orthodontic checklist to reduce the incidence of these errors were considered in the fourth part of the questionnaire in a 3-point Likert scale of likelihood (Yes-No-Maybe).

Data Analysis

The data collected from the questionnaire were coded and entered into Statistical Package for the Social Sciences (SPSS) version 22 and descriptive statistic were used to analyze the categorical variables.

Results

Consultants 31(58.5%) formed a large percentage of those who took part in the survey. Majority of the participants practice in the tertiary health facility 40(75.5%) and 41.5% of the respondents have been practicing for more than 10 years. (Table 1).

Table 1. Distribution of the study participants

	Groups	n (%)
Age (Years)		
	≥ 30 - < 40	48 (45.3)
	≥ 40 - < 50	16 (30.2)
	≥ 50 - < 60	11 (20.8)
	≥ 60	2 (3.9)
Gender		
	Male	22(41.5)
	Female	31 (58.5)
DOP (Years)		
	≥ 1 - < 5	15 (28.3)
	≥ 5 - < 10	16 (30.2)
	≥ 10	22 (41.5)
LOP		
	PP	8 (15.1)
	SHF	5 (9.4)
	THF	40 (75.5)
Designation		
	Registrar	4 (7.5)
	S/Registrar	16 (30.2)
	Certified	2 (3.8)
	Consultant	31 (58.5)

Key: S/Registrar: Senior Registrar, DOP: Duration of practice, LOP: Location of practice, PP: private practice, SH: Secondary health facility, THF: Tertiary health facility

The results shows that 15(28.3%) participants had only be practicing for less than 5 years and registrars form 3(20%) of the group. Among the 22(41.5%) participants that have been practicing for more than 10 years, majority 16(72.7%) were consultants. Majority of the participants 40 (75.5%) practiced in tertiary health facility and a larger percentage 19(47.5%) of them were consultants. All the registrars, 4 (10%) and senior registrars 16 (40%), were all receiving training in the tertiary health facility (Table 2).

Table 2. Distribution of study participants in relation to duration and location of practice.

	Registrar n (%)	S/Registrar n (%)	Certified n (%)	Consultant n (%)	Total n (%)
DOP (Years)					
>1 - <5	3 (20.0)	5 (33.3)	0 (0.0)	7 (46.7)	15 (28.3)
>5 - <10	1 (6.3)	6 (37.5)	1 (6.3)	8 (30.2)	16 (30.2)
>10	0 (0.00)	5 (22.7)	1 (4.5)	16 (72.7)	22 (41.5)
LOP					
PP	0 (0.00)	0 (0.00)	1 (12.5)	7 (87.5)	8 (15.1)
SHF	0 (0.00)	0 (0.00)	0 (0.00)	5 (100.0)	5 (9.5)
THF	4 (10.0)	16 (40.0)	1 (2.50)	19 (47.5)	40 (75.5)

Key: S/Registrar: Senior Registrar, DOP: Duration of practice, LOP: Location of practice, PP: private practice, SHF: Secondary health facility, THF: Tertiary health facility

The errors mostly encountered by the respondents were wrong bracket positioning, missed ligation and non-placement of bend-backs when they are indicated. All 53(100%) respondent either rarely 14(26.4%) or sometimes 39 (73.6%) make the error of positioning brackets wrongly. Among the 53 respondents, 51 (96.2%) make the mistake of missed ligation and non-placement of bend-back when indicated. Also, among those that encountered failure to place bend-back when indicated, 26(49.1) rarely, 19(35.8%) sometimes while 6(11.3%) often make that mistake. Unintentional inversion of brackets during bonding 38(71.7%) and wrong choice of power chain 37(69.8%) followed closely among the errors encountered by respondents. The least errors mostly encountered were the placement of bend-back when not indicated 23(43.4%) followed by unintentional use of wrong archwire materials and the error of swapping archwires between the arches, 28(52.8%) each (Table 3).

Table 3. Estimation of the errors commonly encountered in clinical practice

Variables	Never n (%)	Rarely n (%)	Sometimes n (%)	Often n (%)	Always n (%)	Total n (%)
Unintentional inversion of bracket	15 (28.3)	36 (67.9)	2 (3.8)	-	-	38 (71.7)
Wrong bracket position	-	14 (26.4)	39 (73.6)	-	-	53 (100)
Unintentional use of wrong archwire material	25 (47.2)	22 (41.5)	6 (11.3)	-		28 (52.8)
Wrong archwire gauge	23 (43.3)	22 (41.5)	6 (11.3)	2 (3.8)	-	30 (56.6)

Mistakenly swap upper and lower archwires	25 (47.2)	22 (41.5)	6 (11.3)	-	-	28 (52.8)
Missed ligation	2 (3.8)	30 (56.6)	20 (37.7)	1 (1.9)	-	51 (96.2)
Forgot to place cinch/bend back when indicated	2 (3.8)	26 (49.1)	19 (35.8)	6 (11.3)	-	51 (96.2)
Place cinch/bend back when not indicated	30 (56.6)	21(39.6)	2 (3.8)	-	-	23 (43.4)
Wrong elastic gauge	18 (34.0)	21 (39.6)	14 (26.4)	-	-	35 (66)
Wrong power chain	16 (30.2)	19 (35.8)	18 (34.0)	-	-	37 (69.8)
Wrong molar band	22 (41.5)	27 (50.9)	4 (7.5)	-	-	31(58.4)

Key: TOTAL-ECE; Total error commonly encountered.

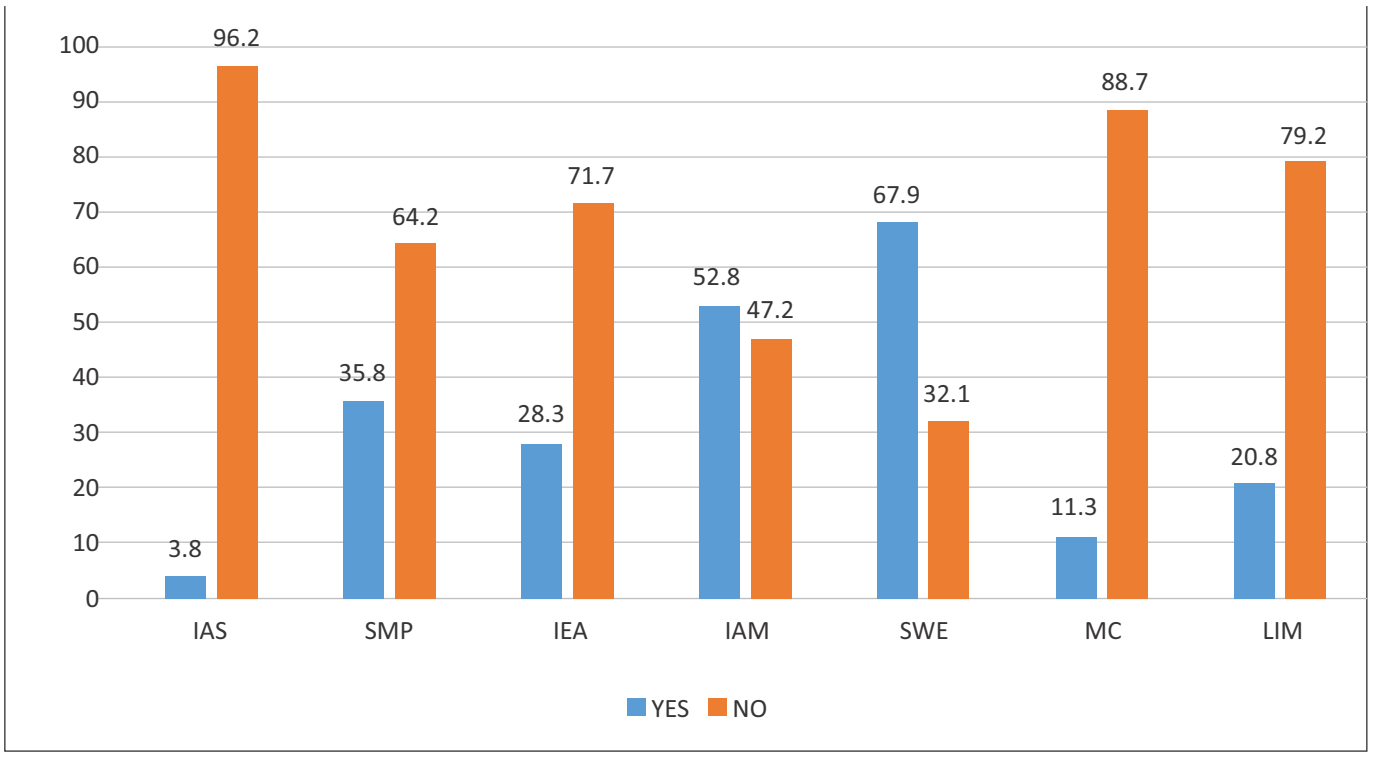

Figure 1. Estimation of the common causes of the errors encountered in orthodontic practice

Key: IAS; Inadequate supervision; SMP; Shortage of man power; IEA; Inexperienced assistant; IAM; Inadequate materials; SWE; Stressful working environment; MC: Medically compromised; LIM: Lack of identification mark

Stressful working environment 67.9%, inadequate materials 52.8% and shortage of manpower 35.8% were responsible for the errors commonly encountered by the respondents (Fig. 1)

Table 4 shows that most of the participants 30(56.6%) agree that orthodontic checklist will help to reduce the incidence of unintended errors in orthodontic clinical practice. Majority of the registrars, 75%, agree that orthodontic checklist will reduce such errors. Among the consultants, 15(48.4%) were in the affirmative while another 15(48.4%) were not sure.

Larger percentages of senior registrars 13(81.3%) and registrars 3(75%) were willing to apply orthodontic checklist in their practice. In total, 35(66.6%) of the participants were willing to apply the orthodontic checklist in their practice.

Table 4. Relevance of the orthodontic checklist and willingness of participants to apply it

	Designation				
	Registrar	**S/Registrar**	**Certified**	**Consultant**	**Total**
	n (%)	n (%)	n (%)	n (%)	n (%)
ROCL					
Yes	3(75.0)	11 (68.8)	1 (50.0)	15 (48.4)	30(56.6)
No	1 (25)	-	-	1 (3.2)	2(3.8)
Maybe		5(31.3)	1(50.0)	15(48.4)	21(39.6)
WTAOCL					
Yes	3(75.0)	13(81.3)	1(50.0)	18(58.1)	35(66.0)
No	1(25.0)	-	-	1(3.2)	2(3.8)
Maybe	-	3(18.8)	1(50.0)	12(38.7)	16(30.2)

KEY: ROCL: Relevance of orthodontic checklist; WTAOCL: Willingness to apply orthodontic checklist.

Discussion

Excellent treatment outcome is the goal of every orthodontic treatment. This expected outcome can only be achieved through thorough treatment planning and implementation. Fixed orthodontic appliance therapy involves a lot of bio-mechanotherapy that requires the skill and knowledge of the orthodontist. The implementation of the treatment plan therefore means that errors should be eliminated or reduced to the barest minimum. Errors in orthodontic clinical practice can be encountered during bracket positioning, archwire selection, archwire ligation and the proper application of the right gauge of power chain, among others. Even though the various aspects as listed, form an integral part of fixed orthodontic treatment, the incidence of unintended errors usually encountered by clinicians appear not to be sufficiently indexed in the literature. This present study was conducted to estimate the incidence of the errors commonly encountered in orthodontics clinical practice in Nigeria.

In this current study, wrong bracket position with regard to placement on the facial axis of the clinical crown was mostly encountered by the respondents. The respondents either rarely (26.4%) or sometimes (73.6%) make the error of placing orthodontic brackets wrongly. The risk of errors in bracket positioning had earlier been reported between

clinicians when bonding in various areas of the mouth.[1] Errors in bracket positioning are usually expressed during the leveling and alignment stage and the ability to recognize and activate early corrective measures would reduce the need for wire bending. Clinicians are advised to always take into consideration the use of even adhesives, pressure application, crown morphology, assessment of root positioning on dental panoramic radiograph and possible repositioning of brackets for best treatment outcome.[1] In order to minimize the error of wrong bracket positioning, several guidelines have been suggested.[13,14] Recently, with the incorporation of customized orthodontic philosophy and digital orthodontics, customize bracket can now be transferred accurately to the tooth surface thereby leading to significant reduction in the errors encountered during bracket positioning.[1] In another study, it was reported that the use of bracket holding plier also helps to prevent and reduce the incidence of error encountered during bracket position and that the method was adjudged to be simple, convenient with less chair side time.[15] The 5-step protocol proposed by Carlson & Johnson could be useful in order to reduce errors encountered during bracket positioning in clinical practice.[16]

Also in this present study, errors associated with archwire (choice of archwire materials [52.6%], archwire gauge [56.6%] and erroneous archwire swab [52.6%] were among the least reported errors. In order to be able to make the right selection of archwire, orthodontists must have the requisite knowledge of the biomechanical property and clinical application of archwires. For example, the need for light and continuous force during the initial stages of fixed orthodontic therapy informs the choice of the clinician towards selecting superelastic wire like nickel-titanium alloy with long range of action and shape memory. On the other hand, stainless steel wire is more rigid with less springback making them suitable for the finishing stage of treatment.[17] Preservation of arch form is key in achieving stable outcome and unintended expansion caused by wrong choice of archwire would lead to instability. The use of identification marks on the archwire could minimize the errors of swapping arch wires between the jaws.

Furthermore, stressful working environment, inadequate materials and shortage of manpower were the major factors considered to be responsible for the errors encountered. Stress in orthodontic workplace has been reported as a critical factor to be considered in clinical practice. Stressors among orthodontic practitioners are related to poor patient compliance and having to deal with uncooperative patients and also those related to time management such as patients arriving later than their scheduled appointment time.[18] Attending to a patient that presents late for clinic appointment could make the clinician hurryingly treat the patient thereby predisposing to errors. Therefore, proper time management could address most of the problems related to stress among orthodontists.[19] The challenges of inadequate orthodontic materials like brackets, bands, archwires and power chain is a key factor that determines what is available in the clinic at every given time for the treatment of patients during clinic appointments. Orthodontic treatments in most of the tertiary health facility in Nigeria are funded by the government and when there is shortage of orthodontic materials, the clinician may be forced to make use of what is available. This is a major cause of the error of archwire swab, wrong power chain and wrong molar bands.

Also, in this study majority of the respondents (56.6%) agree that the orthodontic checklist is an invaluable tool in orthodontic practice, out of which 66.0% were willing to apply it. This finding agrees with the position of another a previous who reported that checklist helps to reduce errors in clinical practice and strengthen adherence to standard guidelines.[20] After every clinical appointment, it is therefore needful to carry out an immediate post-treatment review using the checklist, to ensure that the intended mechanotherapy will result in an expected outcome.

Conclusion

Estimation of unintended errors in orthodontic clinical practice among clinicians in Nigeria has shown that the most occurring errors were: wrong bracket position, missed ligations of the archwires into the bracket slots and non-placement of bend-

back when it was indicated. The respondents identified three topmost causes of the errors they encounter in clinical practice which include: stressful working environment, inadequate materials and shortage of manpower. Furthermore, the participants also believed that the use of orthodontic checklist would help to reduce the incidence of these errors.

Recommendation

There is a need to develop a standard and universally applicable orthodontic start-up and follow-up checklists. This will help clinician adhere to standard treatment protocol and reduce the errors encountered. This checklist will also reduce the stress encountered by orthodontists in practice.

Contribution to Authorship

Author OAA developed the concept of the research work, Authors OAA and TEA designed the study and participated in the data collection and data interpretation. Both authors approved the paper for publication and agreed to be accountable for all aspects of the research. Both authors read and approved the final manuscript.

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Conflicting Interests

Authors have declared that no competing interests exist.

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