Original articles

An assessment of clinical characteristics, radiographic features, and patient conditions in endodontic treatment based on the American Association of Endodontists case difficulty assessment form

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Abstract

Background: Accurate assessment of endodontic case difficulty before treatment is essential to reduce procedural errors. The American Association of Endodontists (AAE) (2022) developed a standardized case difficulty assessment form to classify endodontic cases into low-, moderate-, and high-difficulty levels.

Objectives: To describe clinical and radiographic characteristics, patient conditions, and classify endodontic case difficulty according to the 2022 AAE assessment form at Hue University of Medicine and Pharmacy Hospital, and to investigate endodontic procedural errors associated with case difficulty.

Methods: A prospective assessment was conducted on 60 teeths from 52 patients diagnosed with pulpal and/or periapical diseases indicated for non-surgical endodontic treatment at Hue University of Medicine and Pharmacy Hospital from December 2024 to August 2025. All cases underwent clinical and radiographic examination and were classified using the AAE case difficulty assessment form. Postgraduate trainee dentists performed endodontic treatments, and procedural errors were recorded based on radiographic criteria.

Results: High-difficulty cases accounted for 80.0%, while moderate-difficulty cases accounted for 20.0%; no low-difficulty cases were identified. The most common procedural errors were overfilling (18.3%) followed by underfilling, ledge formation (15.0%), inhomogeneity, lack of taper (10.0%), instrument separation (6.7%), and perforation (5%). Procedural errors occurred exclusively in high-difficulty cases, accounting for 41.7%. A statistically significant association was found between endodontic case difficulty and procedural errors ($p < 0.05$), whereas no significant association was observed between case difficulty and specific error types ($p > 0.05$).

Conclusions: The AAE endodontic case difficulty assessment form is a valuable tool for clinical decision-making. High-difficulty cases predominated and were significantly associated with a higher incidence of procedural errors.

Keywords: *endodontic case difficulty assessment; endodontic procedural errors.*

1. INTRODUCTION

The American Association of Endodontists (AAE) has introduced a Case Difficulty Assessment Form to classify endodontic cases into low-, moderate-, and high-difficulty levels. The assessment form is divided into sections, including patient considerations, diagnosis–treatment considerations, and additional considerations, thereby providing an objective tool for effective and consistent classification of endodontic case difficulty [1]. This form assists general practitioners in planning endodontic treatment and deciding whether to proceed with treatment or refer the case to an endodontic specialist.

Worldwide, several studies have investigated the AAE Endodontic Case Difficulty Assessment Form, including those by Haug et al. (2018), Ruaa A. et al. (2019), Reetta P. et al. (2021), and Amal A. et al. (2022). These studies aimed to evaluate the validity of the case difficulty assessment form and to investigate procedural errors occurring during and after endodontic treatment. All reported a common conclusion that the difficulty level of endodontic cases is significantly associated with endodontic procedure errors. The errors evaluated included overfilling, underfilling of the root canal, over-instrumentation beyond the apex, canal ledging, instrument fracture, perforation, and other less common procedural errors. These studies also recommended that clinicians use this form to appropriately match case difficulty to their level of expertise, highlighting its high educational value for dental students and newly graduated dentists. Accordingly, the application of the endodontic case difficulty assessment form before treatment is

considered essential to minimize procedural errors and to achieve successful treatment outcomes for both patients and clinicians [2, 3, 10, 15].

Currently, in Vietnam, studies related to the clinical application of the AAE Endodontic Case Difficulty Assessment Form remain limited. Therefore, we conducted this study entitled: An assessment of clinical characteristics, radiographic features, and patient conditions in endodontic treatment based on the American Association of Endodontists case difficulty assessment form.

Study Objectives

(1) To describe the clinical and radiographic characteristics, patient status, and to classify the difficulty levels of endodontic cases according to the 2022 American Association of Endodontists Case Difficulty Assessment Form at Hue University of Medicine and Pharmacy Hospital.

(2) To investigate endodontic procedural errors associated with case difficulty.

2. MATERIALS AND METHODS

A convenience sample consisting of 60 teeth from 52 patients diagnosed with pulpal and periapical diseases was recruited from the Department of Odonto-Stomatology, Hue University of Medicine and Pharmacy Hospital, from December 2024 to August 2025.

Inclusion criteria: Permanent teeth with complete apical closure diagnosed with pulpal and/or periapical diseases according to the American Association of Endodontists classification (2013) and indicated for non-surgical endodontic treatment, including pulpal diseases (symptomatic irreversible pulpitis, asymptomatic irreversible pulpitis, pulp necrosis, previously treated, and previously initiated therapy), and periapical diseases (symptomatic apical periodontitis, asymptomatic apical periodontitis, acute apical abscess, and chronic apical abscess). Patients were required to be cooperative throughout the treatment process.

Exclusion criteria: Pregnant patients (radiographic examination contraindicated); teeth not indicated for endodontic treatment, including teeth with Grade III mobility according to Miller (1938); teeth with root caries or furcation caries; teeth with internal resorption resulting in perforation; teeth with root cracks or root fractures; teeth deemed unrestorable after treatment; and teeth with abnormal root morphology or obliterated root canals.

Study Procedure

Step 1: Clinical examination, assessment, and recording of clinical and radiographic findings.

Step 2: Selection of patients who met the inclusion criteria for enrollment in the study sample.

Step 3: Medical history taking, clinical examination, and completion of the research data collection form.

Step 4: Monitoring the endodontic treatment procedures performed by postgraduate trainee dentists.

Step 5: Radiographic evaluation using periapical radiographs obtained during treatment and immediately after root canal obturation, with findings recorded on the research data collection form.

Step 6: Data entry, data cleaning, coding, processing, and statistical analysis.

Study variables and data analysis

The study variables included:

General characteristics: sex, age, and patient status (medical history, anesthesia, patient disposition, ability to open mouth, gag reflex, and emergency condition).

Clinical characteristics: diagnosis, radiographic difficulty, tooth position, tooth isolation, and crown morphology.

Radiographic characteristics: root canal and root morphology, proximity of the root apies to vital structures and resorption.

Classification of endodontic case difficulty according to the AAE (2022) [1]:

- Low difficulty: cases presenting factors listed in the low difficulty category.
- Moderate difficulty: cases presenting one or two factors listed in the moderate difficulty category.
- High difficulty: cases presenting three or more factors listed in the moderate difficulty category or at least one factor listed in the high difficulty category.

Assessment of procedural errors based on periapical radiographs according to Bhavin Bhuva et al. (2020) [5]: ledge formation, defined as obturation material terminating short of the working length; deviation of radiopaque filling material from the original root canal path; perforation, defined as filling material passing through the lateral wall of a curved root or extrusion of filling material laterally from the root; and instrument separation, identified by visualization of a fractured instrument within the root canal or the presence of the instrument tip in the periapical area on radiographs.

Assessment of post-obturation errors based on the radiographic evaluation criteria for root canal filling quality according to Schilder (1974)

[16]: underfilling, defined as obturation material terminating 0 - 2 mm short of the radiographic apex; overfilling, defined as extrusion of obturation material beyond the radiographic apex; lack of taper, defined as the absence of continuous taper from the canal orifice to the apical extent of the filling; and inhomogeneity, defined as low uniform density of the obturation material and/or the presence of voids between the filling material and the canal walls.

Clinical examinations and radiographic evaluations were performed by two postgraduate trainee dentists (one examiner and one recorder) and two endodontists, all of whom were calibrated and standardized regarding evaluation criteria and data recording. Digital periapical radiographs were obtained using the bisecting-angle technique, with adequate image quality allowing clear differentiation of anatomical structures.

Data analysis: Collected data were entered and cleaned in Microsoft Excel, and analyzed in R. Results were presented as tables and percentage charts. Proportions were compared using Fisher's exact test, with a significance level set at $p < 0.05$ and a confidence level of 95%.

The study protocol was approved by the Biomedical Research Ethics Committee of Hue University of Medicine and Pharmacy (approval number H2024/606, dated November 12, 2024).

3. RESULTS

3.1. Clinical characteristics, radiographic findings, patient conditions, and classification of endodontic case difficulty

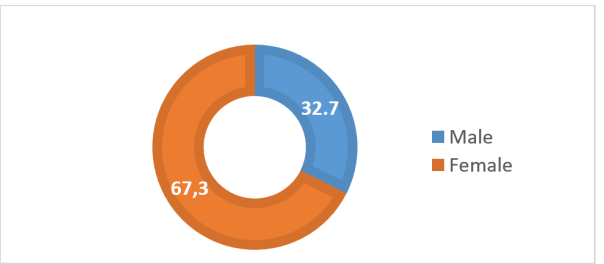

Figure 1. Distribution of patients by gender (%)

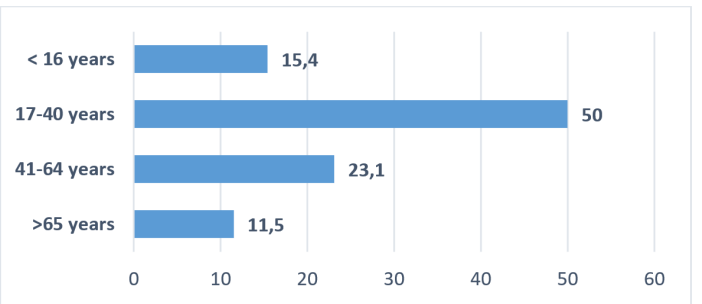

Figure 2. Distribution of patients by age group (%)

In this study, 35 female patients (67.3%) were enrolled, compared with 17 male patients (32.7%). The 17–40 age group accounted for the highest proportion (50.0%), which was markedly higher than the under-16 age group (15.4%) and the 41- 64 age group (23.1%), while individuals aged 65 years and above accounted for the lowest proportion (11.5%).

Table 1. Patient Condition

	Characteristic	Quantity (%)
Medical history	No medical problem	35 (67.3)
	One or more medical problem	17 (32.7)
	Complex medical history/ Serious Illness/Disability	0 (0.0)

Anesthesia	No history of anesthesia problems	52 (100.0)
	Vasoconstrictor intolerance	0 (0.0)
	Difficulty achieving and/or maintaining anesthesia	0 (0.0)
Patient disposition	Cooperative and compliant	50 (96.2)
	Anxious but cooperative	2 (3.8)
	Uncooperative	0 (0.0)
Ability to open mouth	No limitation	52 (100.0)
	Slight limitation in opening	0 (0.0)
	Significantly limitation in opening	0 (0.0)
Gag reflex	None	49 (94.2)
	Gags occasionally with radiographs /treatment	3 (5.8)
	Extreme gag reflex which has compromised past dental care	0 (0.0)
Emergency Conditions	Minimum Pain or Swelling	29 (55.8)
	Moderate Pain or Swelling	18 (34.6)
	Severe Pain or Swelling	5 (9.6)

A total of 32.7% of patients had one or more medical problem. Gags occasionally with radiographs / treatment was observed in 5.8% of patients, and 3.8% anxious but cooperative. All cases demonstrated a mouth opening greater than 4 cm and no history of anesthesia problems. The majority of patients presented with minimum pain or swelling (55.8%), whereas severe pain or swelling accounted for only 9.6% of cases.

Table 2. Clinical Characteristics of Endodontic Cases

	Clinical Characteristic	Quantity (%)
Diagnosis	Signs and symptoms consistent with recognized pulpal and periapical conditions	57 (95.0)
	Extensive differential diagnosis of usual signs and symptoms required	3 (5.0)
	Confusing and complex signs and symptoms: difficult diagnosis	0 (0.0)
	History of chronic oral/facial pain	0 (0.0)
Position	Anterior teeth	11 (18.3)
	Premolars	17 (28.3)
	1st molars	22 (36.7)
	2nd and 3rd molars	10 (16.7)
Inclination	Slight inclination (< 10 degrees)	55 (91.7)
	Moderate inclination (10 - 30 degrees)	2 (3.3)
	Extreme inclination (> 30 degrees)	3 (5.0)
Rotation	Slight rotation (< 10 degrees)	60 (100.0)
	Moderate rotation (< 10 degrees)	0 (0.0)
	Extreme rotation (> 10 degrees)	0 (0.0)
Isolation	Routine rubber dam placement	52 (86.7)
	Simple pretreatment modification required for rubber dam isolation	8 (13.3)
	Extensive pretreatment modification required for rubber dam isolation	0 (0.0)
Crown Morphology	Teeth with extensive coronal destruction	40 (66.7)
	Normal original crown morphology	17 (28.3)
	Crowned Tooth	2 (3.3)
	Tooth in Tooth	1 (1.7)

In this study, the majority of signs and symptoms consistent with recognized pulpal and periapical conditions (95%). The first molars accounted for the highest proportion of cases (36.7%). Most teeth exhibited slight inclination (< 10 degrees), accounting for 91.7%, and all teeth demonstrated slight rotation of less than 10 degrees. Simple pretreatment modification required for rubber dam isolation in 13.3% of cases, while routine rubber dam placement in the majority (86.7%). Teeth with extensive coronal destruction due to caries represented the largest proportion (66.7%).

Table 3. Radiographic Characteristics of Endodontic Cases on Periapical Radiographs

Characteristics		Quantity (%)
Radiographic difficulties	Minimal difficulty obtaining/interpreting radiographs	51 (85.0)
	Moderate difficulty obtaining/interpreting radiographs	4 (6.7)
	Extreme difficulty obtaining/interpreting radiographs	5 (8.3)
Canal appearance on radiographs	Canal(s) and chamber visible and not reduced in size	36 (60.0)
	Canal(s) and chamber visible but reduced in size	19 (31.7)
	Indistinct canal path Canal(s) and chamber not visible	5 (8.3)
Pulp stones	Yes	7 (11.7)
	No	53 (88.3)
Canal curvature	Straight/slight curvature (< 10°)	25 (41.7)
	Moderate curvature (10 - 30°)	24 (40.0)
	Extreme curvature or S-shaped (> 30°)	11 (18.3)
Apex	Closed apex (< 1 mm in diameter)	56 (93.3)
	Apical opening (1 - 1.5 mm in diameter)	4 (6.7)
	Open apex (> 1.5 mm in diameter)	0 (0.0)
Resorption	No resorption evident	51 (85.0)
	Minimal apical resorption	8 (13.3)
	Internal resorption	1 (1.7)
	External resorption	0 (0.0)
Proximity of the root apices to vital structures such as the ian or mental foramen	Vital structures 5 or more millimeters from apices	52 (86.7)
	3 - 5 millimeters	4 (6.7)
	< 3 millimeters	4 (6.7)

The majority of cases presented minimal difficulty obtaining/interpreting radiographs (85%). Canal(s) and chamber visible and not reduced in size in 60.0% of cases, and pulp stones were absent in 88.3%. The proportion of endodontically treated teeth with root canal curvature of <10 degrees was 41.7%, while those with curvature of 10–30 degrees accounted for 40.0%. Most cases exhibited a closed apex (93.3%). The majority of teeth showed no radiographic evidence of resorption (85.0%). In most cases, vital structures 5 or more millimeters from apices (86.7%).

Table 4. Endodontic Case Difficulty Levels According to the AAE

Characteristic		Quantity (%)
Endodontic case difficulty level according to AAE	Low difficulty	0 (0.0)
	Moderate difficulty	12 (20.0)
	High difficulty	48 (80.0)

The majority of endodontic cases were classified as high difficulty (80%), while 20% were classified as moderate difficulty. No cases were classified as low difficulty.

3.2. Assessment of endodontic procedure errors in relation to case difficulty

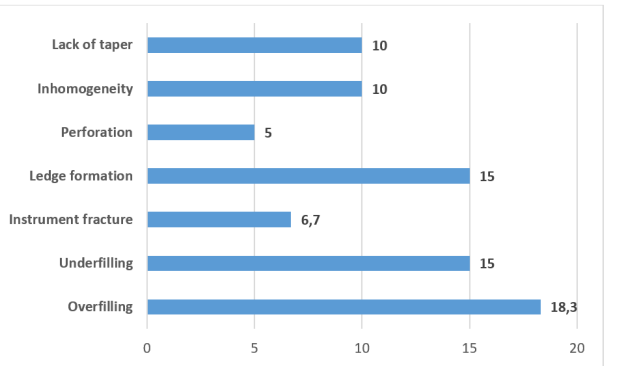

Figure 3. Frequency of technical errors in root canal treatment (%)

The most common procedural errors were related to working length, including overfilling (18.3%), underfilling and ledge formation (15.0%). Perforation was the least frequently observed error, accounting for 5.0% of cases.

Table 5. Association between case difficulty and the occurrence of endodontic procedure errors

Characteristic		Endodontic procedure errors				Total		p-value
		Yes		No				
		n	%	n	%	n	%	
Difficulty of endodontic cases	Low/ Moderate	0	0.0	12	100.0	12	20	**0.007**
	High	25	52.1	23	47.9	48	80	
	Total	25	41.7	35	58.3	60	100	

**Using the Fisher's Exact test*

Our study did not record any procedural errors in cases classified as low or moderate difficulty. All observed errors occurred in the high-difficulty group, with 25 out of 60 high-difficulty cases (41.7%) exhibiting treatment-related errors. A statistically significant association was found between endodontic case difficulty and endodontic procedure errors at the 95% confidence level ($p < 0.05$).

Table 6. Association between case difficulty and specific procedure errors in endodontic treatment

Characteristic		Difficulty level of the endodontic cases		Total	p-value
		Low/ Moderate	High		
Overfilling	Yes	0	11	11	0.09
	No	12	37	49	
Underfilling (> 1 mm)	Yes	0	9	9	0.18
	No	12	39	51	
Instrument fracture	Yes	0	4	4	0.57
	No	12	44	56	
Ledge formation	Yes	0	9	9	0.18
	No	12	39	51	
Perforation	Yes	0	3	3	1.00
	No	12	45	57	
Inhomogeneity	Yes	0	6	6	0.33
	No	12	42	54	
Lack of taper	Yes	0	6	6	0.33
	No	12	42	54	

**Using the Fisher's Exact test*

Results from Table 6 showed differences in procedural error frequency during endodontic treatment according to the difficulty level of endodontic cases. However, the differences between endodontic case difficulty levels and specific procedural error types were not statistically significant ($p > 0.05$ in all comparisons).

4. DISCUSSION

4.1. Clinical characteristics, radiographic findings, patient conditions, and classification of endodontic case difficulty

Among the 52 patients included in the study, females accounted for 67.3% and males for 32.7%. The 17 - 40 age group represented the highest proportion (50.0%). Regarding patient status, 26.7% of patients had at least one medical problem. Most patients had no history of anesthesia problems, and the majority were cooperative during treatment. This may be attributed to the predominance of patients aged 17 - 40 years. This age group generally has better access to oral health knowledge, greater cooperation, and better psychological preparedness due to awareness of dental procedures. Most patients exhibited normal mouth opening, which can be explained by the fact that the majority presented with minimum to moderate pain or swelling, conditions that do not significantly affect mouth opening ability. Most patients did not exhibit a gag reflex. In our study, third molars were not included, and 83.3% of teeth were located anterior to the first molars; therefore, neither treatment nor radiographic procedures involved stimulation of the oropharyngeal region that could induce a gag reflex. In addition, good patient cooperation contributed to the absence of psychogenic gag reflexes. Most patients presented with minimum to moderate pain and swelling (90.4%). This may be explained by the predominance of asymptomatic pulpal and periapical diseases in the study sample, as patients often tend to self-medicate with analgesics before dental visits, resulting in less pronounced clinical symptoms.

Regarding clinical characteristics, most cases (95.0%) exhibited signs and symptoms consistent with recognized pulpal and periapical conditions. First molars accounted for the highest proportion of treated teeth (36.7%). As first molars are the first permanent teeth to erupt in the dental arch (approximately at 6 - 7 years of age), they are at higher risk of early caries and subsequent complications such as pulpal and periapical diseases. Teeth with extensive coronal destruction due to caries were most prevalent (66.7%). Most teeth demonstrated slight inclination (91.7%) and slight rotation (100%). Owing to these characteristics, routine rubber dam placement was feasible in 86.7% of cases, while only 13.3% required simple modifications to facilitate isolation.

Regarding radiographic characteristics, 85.0% of endodontic cases presented minimal difficulty obtaining or interpreting radiographs. This may be attributed to the patients' generally good systemic health, cooperative behavior, no limitation in mouth opening, and absence of a gag reflex. On periapical radiographs, root canals were clearly visible without narrowing in 60.0% of cases, while pulp stones were observed in only 11.7% of cases.

Radiographic evaluation showed that 41.7% of teeth had root canal curvature of < 10°, whereas only a small proportion exhibited extreme curved canals (18.3%). This proportion was higher than that reported by Faraj B.M. (2021), who found that only 6.35% of teeth had moderately to severely curved canals. This discrepancy may be explained by the fact that canal curvature in our study was assessed solely on periapical radiographs. Such images allow evaluation of canal curvature in the mesiodistal direction but do not fully reveal buccolingual anatomical complexities of the root canal system, potentially masking canal complexity and making accurate assessment of canal curvature more challenging [8]. Most evaluated teeth exhibited closed apex (< 1 mm diameter), accounting for 93.3%, which is consistent with the inclusion of fully developed permanent teeth in this study. Apical resorption was observed in a small proportion of cases (13.3%), and internal resorption accounted for only 1.7%; the majority of cases showed no evidence of root resorption. This may be explained by the predominance of cases diagnosed with symptomatic irreversible pulpitis and pulp necrosis, with relatively few cases of apical periodontitis, resulting in a lower prevalence of periapical infection and subsequent root resorption.

According to the 2022 American Association of Endodontists Case Difficulty Assessment Form, low- and moderate-difficulty cases accounted for 20% of the sample, whereas high-difficulty cases accounted for 80%. This proportion of high-difficulty cases was substantially higher than that reported by Haug et al. (2018), in which high-difficulty endodontic cases accounted for 52.9% [10]. This difference may be attributed to the random sampling method and the relatively small sample size used in our study.

4.2. Assessment of endodontic treatment errors in relation to case difficulty

In our study, procedural errors in endodontic treatment were observed in 41.7% of cases (25/60), which is higher than the rate reported by Kulic et al. (2011) at 7% [13] and Alamoudi et al. (2020) at 22.1% [2], but lower than that reported by Haji-Hassani et al. (2015), which reached 66% [9]. According to the recommendations of the American Association of Endodontists (AAE), high-complexity endodontic cases are best managed by endodontic specialists or clinicians with extensive endodontic experience. However, in our study, high-difficulty cases were treated by clinicians with limited endodontic experience. Therefore, the relatively high error rate may reflect a mismatch between the operator's skill level and the complexity of the case.

The most common treatment-related errors identified in our study were root canal overfilling (18.3%), underfilling and ledge formation (15.0%), and lack of taper and obturation inhomogeneity (10.0%). These rates are lower than those reported by Iqbal A. (2016), who observed underfilling beyond the working length in 33.3% of cases and inhomogeneity in 17.7% [11]. In another large-scale study involving 1,000 endodontically treated cases at King Abdulaziz University Dental Clinics, Jeddah, Saudi Arabia (2020), underfilling was the most frequently detected error (8.4%), followed by ledge formation (4.2%), overfilling (4.0%), and instrument separation (3.0%) [2]. Underfilling commonly occurs due to inadequate canal preparation or the formation of canal ledges during instrumentation. Insufficient canal preparation is often associated with inaccurate working length determination or canal blockage caused by inadequate irrigation [14]. Overfilling may result from incorrect working length determination or over-instrumentation beyond the apical constriction, leading to disruption of the apical stop and difficulty in achieving proper obturation. In university dental clinics, over-instrumentation may be attributed to insufficient attention to apical stops or to displacement of the apical stop during forceful, uncontrolled instrumentation [8].

The incidence of ledge formation in our study was 15.0%, which is markedly lower than the rate reported by Khabbaz et al. (2010) at 54.8% [12], but relatively comparable to the findings of Balto et al. (2010), who reported a rate of 14% [4]. The lower incidence of ledging in our study may be explained by the use of nickel–titanium (NiTi) instruments and preparation techniques such as the crown-down or passive step-back approach [17]. In addition, root canal curvature is a major factor associated with the occurrence of ledge formation [6]. In our study, most teeth exhibited slight to moderate canal curvature, which may account for the differences compared with other studies.

Instrument separation within the root canal was observed in 6.7% of cases, which is higher than the rates reported by Iqbal et al. (2016) at 1.9% and Haug et al. (2018) at 2.3% [10, 11]. Root canal perforation was the least frequently observed error in our study, accounting for 5.0% of cases. This rate is considerably lower than that reported by Eskandarloo et al. (2017), who observed perforations in 17.6% of cases [7], but higher than the 1.9% reported by Yavari et al. (2015) [18]. These differences may be attributed to variations in sample size and the difficulty level of endodontic cases. Root canal perforation can lead to treatment complications, increase case complexity, and, in severe cases, necessitate tooth extraction if the perforation compromises the tooth's prognosis [2].

In this study, among the 60 treated teeth, all 25 teeth that exhibited at least one procedural error were classified as high-difficulty endodontic cases according to the AAE Case Difficulty Assessment Form. No procedural errors were recorded in cases classified as low or moderate difficulty. These findings demonstrate a statistically significant association between AAE endodontic case difficulty and procedural errors at the 95% confidence level ($p < 0.05$). Our results are consistent with those reported by Alamoudi et al. (2020) and Haug et al. (2018), both of which also demonstrated statistically significant associations ($p < 0.01$) [2, 10].

5. CONCLUSIONS

This study highlights the importance of the endodontic case difficulty assessment form, based on clinical characteristics, radiographic findings, and patient conditions, for classifying endodontic cases. The results showed that high-difficulty cases accounted for 80% and moderate-difficulty cases for 20%, with no low-difficulty cases identified. This distribution may be attributed to the small sample size, short study duration, and convenience sampling method.

In addition, the study demonstrated that procedural errors occurred in 41.7% of high-difficulty cases, and a statistically significant association was found between endodontic case difficulty and procedure errors ($p < 0.05$). Awareness of the clinician's skills and experience is essential for appropriate case selection and for minimizing

procedural errors in clinical practice.

Given the relatively small sample size of this study, further investigations with larger samples are warranted to provide a broader perspective on clinical practice. Future studies should also include a greater number of retreatment cases in addition to primary endodontic treatment cases.

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