

How much does the lack of update cost? Iatrogenesis in Endodontics under the scientific lens

Quanto custa a falta de atualização? Iatrogenia em Endodontia sob a lupa científica

¿Cuánto cuesta la falta de actualización? Iatrogenia en Endodoncia bajo la lupa científica

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Abstract

Iatrogenesis in endodontics represents a significant challenge in daily clinical practice, as it can directly affect the prognosis of treatment and the patient's overall health. Despite technological advancements in imaging, rotary instrumentation, magnification, and obturation materials, complications arising from operator errors remain frequent. The main iatrogenic incidents in endodontics include perforations of the pulp chamber floor or root walls, instrument fractures, over-instrumentation, overfilling, canal transportation, ledges, blockages, and untreated canals. These complications often stem from a lack of understanding of internal tooth anatomy, inadequate planning, negligence, improper use of technology, or pressure due to limited clinical time. The consequences can range from persistent symptoms to complete treatment failure, necessitating re-intervention or even tooth extraction. This article aims to describe the most common iatrogenic incidents occurring during endodontic treatment, analyze their primary causes and consequences, and present strategies for prevention and management. A qualitative narrative review research was carried out. Emphasis is placed on the importance of proper professional training, the use of evidence-based clinical protocols, the adoption of new diagnostic and treatment technologies, and effective communication with the patient. Preventing iatrogenesis should be a priority in endodontic practice, as it not only ensures better clinical outcomes but also strengthens patient trust in the dental professional, contributing to ethical and safe dental care.

Keywords: Iatrogenesis; Endodontics; Medical Errors; Postoperative Complications.

Resumo

A iatrogenia na endodontia representa um desafio significativo na prática clínica diária, pois pode afetar diretamente o prognóstico do tratamento e a saúde geral do paciente. Apesar dos avanços tecnológicos em imagens, instrumentação rotatória, ampliação e materiais de obturação, as complicações decorrentes de erros do operador continuam frequentes. Os principais incidentes iatrogênicos em endodontia incluem perfurações do assoalho da câmara pulpar ou paredes radiculares, fraturas de instrumentos, instrumentação excessiva, sobrepreenchimento, transporte do canal, degraus, bloqueios e canais não tratados. Essas complicações geralmente decorrem da falta de compreensão da anatomia interna do dente, planejamento inadequado, negligência, uso incorreto da tecnologia ou pressão devido ao tempo clínico limitado. As consequências podem variar de sintomas persistentes à falha completa do tratamento, necessitando de reintervenção ou até extração do dente. Este artigo tem como objetivo descrever os incidentes iatrogênicos mais comuns que ocorrem durante o tratamento endodôntico, analisar suas principais causas e consequências, e apresentar estratégias para prevenção e manejo. Foi realizada uma pesquisa narrativa qualitativa. A ênfase é dada à importância do treinamento profissional adequado, uso de protocolos clínicos baseados em evidências, adoção de novas tecnologias diagnósticas e terapêuticas, e comunicação eficaz com o paciente. A prevenção da iatrogenia deve ser prioridade na prática endodôntica, pois não só garante melhores resultados clínicos, mas também fortalece a confiança do paciente no profissional, contribuindo para um atendimento odontológico ético e seguro.

Palavras-chave: Iatrogenia; Endodontia; Erros Médicos; Complicações Pós-operatórias.

Resumen

La iatrogenia en endodoncia representa un desafío significativo en la práctica clínica diaria, ya que puede afectar directamente el pronóstico del tratamiento y la salud general del paciente. A pesar de los avances tecnológicos en imágenes, instrumentación rotatoria, magnificación y materiales de obturación, las complicaciones derivadas de errores del operador siguen siendo frecuentes. Los principales incidentes iatrogénicos en endodoncia incluyen perforaciones del piso de la cámara pulpar o paredes radiculares, fracturas de instrumentos, sobrinstrumentación, sobreobtusión, transporte del conducto, escalones, bloqueos y conductos no tratados. Estas complicaciones suelen originarse por falta de comprensión de la anatomía interna del diente, planificación inadecuada, negligencia, uso incorrecto de la tecnología o presión por el tiempo clínico limitado. Las consecuencias pueden ir desde síntomas persistentes hasta el fracaso total del tratamiento, requiriendo reintervención o incluso la extracción del diente. Este artículo tiene como objetivo describir los incidentes iatrogénicos más comunes que ocurren durante el tratamiento endodóntico, analizar sus principales causas y consecuencias, y presentar estrategias para la prevención y el manejo. Se realizó una investigación narrativa cualitativa. Se enfatiza la importancia de la formación profesional adecuada, el uso de protocolos clínicos basados en la evidencia, la adopción de nuevas tecnologías diagnósticas y terapéuticas, y una comunicación eficaz con el paciente. La prevención de la iatrogenia debe ser una prioridad en la práctica endodóntica, ya que no solo asegura mejores resultados clínicos, sino que también fortalece la confianza del paciente en el profesional, contribuyendo a una atención odontológica ética y segura.

Palabras clave: Iatrogenia; Endodoncia; Errores Médicos; Complicaciones Postoperatorias.

1. Introduction

Iatrogenesis is defined as any harm or adverse effect suffered by a patient because of medical intervention. This may occur due to an error, lack of care, or insufficient experience on the part of the healthcare professional during diagnosis, treatment, prevention, or rehabilitation. The term "iatrogenesis" originates from the Greek word "iatrogénesis," which means "caused or generated by the physician or healer." It is composed of two Greek words: "iatros" (physician) and "génesis" (origin or creation) (Spielman, 2024; Cintra et al., 2021).

With the development of modern dentistry in the 19th and 20th centuries, the study of dental anatomy, the development of biocompatible materials, and the use of specialized tools and adherence to biosafety protocols in dental treatments have significantly reduced iatrogenic incidents. However, these complications have not been completely eliminated. Today, errors such as root perforations in endodontics or improper handling of chemical substances remain challenges in dental practice (Gupta et al., 2020; Setzer et al., 2022).

Understanding when and why endodontic treatments fail is a fundamental pillar for dentists and endodontic specialists to establish more accurate prognoses and, consequently, improve long-term clinical outcomes. Numerous studies have identified that one of the main factors associated with endodontic failure is the presence of additional root canals that were not identified or treated during initial therapy. This omission, often attributed to an incomplete interpretation of the complex morphology of

the root canal system, can lead to the persistence of microorganisms, chronic inflammation, or recurrence of clinical symptoms (Jang et al., 2024; Dioguardi et al., 2022).

Although the complete eradication of iatrogenic incidents in dentistry is unattainable, their occurrence can be drastically reduced through the proper application of the so-called "3 Ts": Training, Technique, and Technology. These three pillars do not act in isolation but continuously reinforce one another, with training serving as the essential starting point for mastering both technique and available technology. In this regard, the use of the dental operating microscope (DOM) and cone-beam computed tomography (CBCT) has revolutionized modern clinical practice, enabling more accurate treatment planning and more precise diagnosis (Berman, 2022). These tools not only optimize the localization of root canals, even in highly complex anatomies, but also facilitate the detection of periapical pathology, the removal of fractured instruments, and the repair of perforations.

This article aims to describe the most common iatrogenic incidents occurring during endodontic treatment, analyze their primary causes and consequences, and present strategies for prevention and management.

2. Methodology

A mixed research of a qualitative nature and of the bibliographic review type (Snyder, 2019) and of the specific type of narrative literature review (Casarin et al., 2020; Rother, 2007) was carried out using the Google Scholar database and the search terms: Iatrogenesis, Endodontics, Medical Errors, Postoperative Complications. Following this, a comprehensive analysis and synthesis of the selected scientific articles published in recent years was conducted to identify the main iatrogenic incidents in endodontics, their causes, consequences, and prevention strategies.

3. Results and Discussion

3.1 Definition of Iatrogenic Incidents in Endodontics

To address iatrogenesis in endodontics, it is first necessary to understand its concept in dentistry: it refers to any condition or change induced by dental procedures, although the negative consequences are of greater concern due to their medico-legal implications. These are often associated with negligence, recklessness, or lack of skill. In endodontics, iatrogenic incidents may arise from incorrect diagnoses or improper management of dentoalveolar trauma. Despite technological advancements that have enabled the preservation of teeth once considered unsalvageable, technology should serve as a support to clinical judgment, not a substitute for it (Duran et al., 2024).

Endodontists must have comprehensive knowledge of the causes, preventive strategies, and effective corrective measures for each type of endodontic complication. Furthermore, it is essential that they understand how each specific complication may affect treatment prognosis, recognizing that its impact can vary depending on the individual case. In certain clinical situations, a complication may have minimal effects on the overall success of the treatment, while in others, the same endodontic iatrogenesis could jeopardize the final treatment outcome (Mihaela et al., 2024).

3.2 Common Causes of Iatrogenic Incidents in Endodontics

Persistent intraradicular infection, the main cause of periradicular diseases, arises from the presence of bacteria in root canals that have been inadequately treated or left untreated, as well as in dentinal tubules, anatomical irregularities, deltas, and isthmus areas. Additionally, extraradicular causes of root canal treatment failure have been identified, such as periapical actinomycosis, foreign body reactions, accumulation of endogenous cholesterol crystals, and the presence of true cysts.

According to the results of a study conducted by (Young Eun et al., 2024) there are several factors that can increase the risk of making errors or experiencing complications during endodontic procedures. These include:

- Untreated additional canals
- Poor-quality obturation
- Inadequate coronal restoration

These factors are considered critical in influencing the success and long-term prognosis of endodontic treatment. Their presence may lead to persistent infection, treatment failure, or the need for retreatment.

3.3 Types of Iatrogenic Incidents in Endodontics

Ingle. (2019) classifies endodontic accidents according to the treatment phase in which they occur: access, instrumentation, and obturation. (Walton., 2019) expand on this by including complications related to post space preparation. Additionally, (Johnsen.,2024) include other complications such as underpreparation (underextension), overinstrumentation (overextension), canal transportation, and paresthesia. These classifications aid in the accurate identification and effective management of endodontic iatrogenesis, playing a key role in ensuring safe and efficient clinical practice.

3.4 Impact of Iatrogenic Incidents on Treatment Prognosis

3.4.1 Management of Iatrogenic Incidents in Endodontics: Solutions and Treatments

Although undesirable, iatrogenic incidents in endodontics can be effectively managed using clear protocols based on scientific evidence. When an error occurs during endodontic treatment, it is essential to remain calm and perform a detailed evaluation of the problem. Advanced technologies such as cone-beam computed tomography (CBCT) play a crucial role in identifying complications not evident on traditional radiographs, such as perforations, instrument fractures, or canal deviations (Torabinejad et al., 2009).

Cone-beam computed tomography (CBCT) enables precise differentiation between radiolucent lesions of endodontic and non-endodontic origin, improving treatment planning and reducing the risk of misdiagnosis. To make the most of this technology, operators must develop advanced skills in image interpretation. Additionally, the integration of tools such as electronic apex locators, magnification systems, and safe irrigation techniques optimizes complication management, thus enhancing treatment effectiveness (Torabinejad et al., 2009).

Clear, honest, and empathetic communication is crucial when an iatrogenic complication arises in endodontics. It is important to inform the patient transparently about the error, explaining its origin and possible implications for dental health. This openness strengthens trust and ensures compliance with ethical standards. After the explanation, available treatment options should be presented, evaluating risks, benefits, and expectations. Finally, the treatment plan should be adjusted to mitigate the damage caused, ensuring the best possible outcome for the patient.

Post-treatment follow-up is crucial to ensure patient recovery and prevent future complications after an iatrogenic incident in endodontics. Detailed documentation of the event in the clinical record is essential both for legal purposes and adequate monitoring. Regular check-ups allow for assessment of the treatment response and timely adjustments. Furthermore, continuous professional training in advanced techniques and the use of innovative tools, such as simulators and 3D-printed teeth, are fundamental for improving skills and reducing the risk of errors.

To ensure safe and effective endodontic treatment, it is recommended to use state-of-the-art rotary instruments combined with specialized techniques such as the crown-down and step-back methods. These strategies allow for more precise control during root canal instrumentation, especially in curved canals, thereby reducing risks such as canal transportation and instrument fracture. This facilitates more efficient preparation, improves obturation, and reduces long-term complications.

3.4.2 Common Endodontic Errors and Iatrogenic Incidents and Current Solutions

Below are the most frequent errors and current strategies for their management. A general statistic on the frequency of different types of iatrogenic incidents in endodontics is also provided, based on a systematic review of the literature.

3.4.2.1 Root Perforations

Cause: Excessive force during canal preparation or errors in locating root canals—considered critical errors that can have serious consequences, affecting up to 10–20% of cases.

Solution: Early detection of root perforations is vital. Conventional radiography or cone-beam computed tomography (CBCT) allows accurate assessment of the extent of the damage. Immediate sealing with biocompatible materials such as MTA (Mineral Trioxide Aggregate) or Biodentine is crucial to prevent bacterial contamination and save the tooth. Careful planning, including accurate working length determination using electronic apex locators and performing prior radiographs for better planning, is essential. In more severe cases where the perforation is extensive, apical surgery may be necessary, or ultimately, tooth extraction considered (Aslan et al., 2021).

3.4.2.2 Instrument Fracture

Cause: Instrument fracture is a common and critical error that can occur due to overuse, instrument fatigue, improper application of force, or poor technique during treatment, affecting up to 15–25% of cases.

Solution: The removal of a fractured instrument involves the use of ultrasonic devices or specialized systems such as the Micro-Retreat Kit, which facilitate fragment extraction without compromising surrounding structures. Another option is creating a "bypass" of the fractured instrument using fine files, allowing treatment to continue without affecting the integrity of the root canal. In more severe cases where fragment removal is impossible, endodontic surgery may be required to resolve the complication. To prevent these fractures, it is essential to replace worn instruments, avoid metal fatigue, and monitor the case clinically through radiographs (Khatod et al., 2020).

3.4.2.3 Canal Transportation

Cause: Canal transportation occurs when the instrument deviates from the axis of the canal, altering its original shape. This usually happens when rigid files are used or an inadequate technique is applied in curved canals, causing the instrument to stray from the canal axis.

Solution: To prevent and correct this issue, instrumentation techniques such as the "crown-down" method are recommended, which allows gradual preparation of the canal from the crown toward the apex, reducing the risk of transportation. Additionally, rotary systems with flexible designs, such as WaveOne Gold, are particularly effective at adapting to canal curvature and minimizing deviation. In severe cases, preparation of a new apex or endodontic surgery may be necessary to restore canal anatomy (Gajoum et al., 2021).

3.4.2.4 Overfilling or Underfilling

Cause: Resulting from incorrect determination of the working length or insufficient compaction of the filling material.

Solution: Overfilling (occurring in 5–10% of cases) happens when the material extends beyond the apex, damaging periapical tissue. Underfilling (8–15% of cases) occurs when the entire canal is not adequately filled, leading to long-term oral health problems. To avoid these complications, it is essential to use precise filling techniques, such as warm vertical condensation, along with appropriate radiographic control. The use of electronic apex locators is also crucial to minimize errors and improve procedural accuracy.

In addition, careful irrigation is crucial to remove debris from the canal, helping to avoid contamination of the canal system and ensuring effective obturation. The use of intracanal medications, such as calcium hydroxide, is recommended to control inflammation and promote healing in case of infection or irritation of periapical tissue. In cases of persistent pain or complications such as overfilling that may cause inflammation or damage to surrounding tissues, apical surgery may be required to address the affected area and improve the prognosis of the treatment (Lee et al., 2021).

3.4.2.5 Extrusion of Filling Material

Causes: Caused by excessive force during obturation or incorrect measurement of the root canal.

Solution: Extrusion of the filling material can compromise periapical health. If the extrusion is asymptomatic, regular clinical monitoring may be sufficient to ensure no further complications arise. However, in cases where the patient experiences symptoms such as pain or swelling, a more aggressive intervention is required, such as apical surgery to remove the extruded material and properly seal the canal. This approach helps prevent infections and improves the long-term prognosis of endodontic treatment (Çağlar et al., 2024).

3.4.2.6 Furcation or Root Wall Perforation

Causes: Occurs due to excessive wear during instrumentation, especially in multi-rooted teeth with complex anatomies.

Solution: This complication can compromise the structural integrity of the tooth and, in some cases, lead to tooth loss if not properly managed. To address the perforation, the use of biocompatible materials such as MTA or Biodentine is recommended, which are highly effective in sealing the defect and promoting repair of the periapical tissue. These materials offer excellent sealing ability and stimulate bone tissue formation, contributing to the recovery of the affected tooth.

It is essential to prioritize tooth conservation whenever possible. Extraction should only be considered as a last resort, as preserving natural dental structure offers long-term functional and aesthetic benefits. Conservative treatment, including proper sealing of the perforation and continuous monitoring of the tooth, has a high success potential in well-managed cases (Parirokh et al., 2021).

3.4.2.7 Canal Blockage

Causes: Originates from the accumulation of dentinal debris, such as dentin particles or fragments of fractured instruments, which prevent proper instrumentation and cleaning of the root canal.

Solution: To manage this problem, the use of effective irrigating solutions such as sodium hypochlorite and EDTA is recommended, as they have the ability to dissolve dentinal debris and remove organic residues, improving canal cleanliness and facilitating subsequent instrumentation.

After dissolving the debris, small-caliber instruments are used to restore canal permeability without damaging the root walls. Flexible files and controlled irrigation pressure are required to avoid extrusion or perforation. Careful instrumentation allows optimal cleaning and shaping of the canal for effective obturation. Postoperative radiographic and clinical follow-up is crucial to ensure the canal remains free of blockages and that the treatment has a favorable long-term prognosis.

3.4.3 Future Perspectives in the Prevention of Iatrogenesis in Endodontics

Currently, new technologies have been incorporated into endodontics, such as strict guides designed using CAD-CAM to direct a specially designed bur to reach the permeable area of the canal. This requires an initial scanner, a digitized impression of the teeth, and the creation of a guide via digital printing using software. It can be said that the combination of 3D images obtained with computed tomography, together with images from an intraoral scanner, allows for better planning of the procedure.

With this data and the help of software that combines both sets of information, a guide can be designed that allows access to the calcified canal.

The possibilities of iatrogenic damage to the root are reduced, increasing the likelihood of locating the root canal, as root access preparation is improved, thereby reducing treatment time. Research suggests that 3D-printed access guides represent an efficient and safe means of addressing challenging endodontic scenarios, allowing both chemomechanical debridement and preservation of dental structure.

Digital guided endodontics is an effective and precise tool used to locate canals that have been missed, either due to calcification or because the anatomical path was lost during preparation. Thanks to digital planning, unnecessary cervical dentin wear is avoided, reducing both treatment time and the risk of root canal perforation (Kumar et al., 2021).

3.4.4 Consequences of Iatrogenic Incidents in Endodontics

According to (Johnstone., 2022), in a study conducted in Australia, dentists have the highest rates of patient complaints among all healthcare professionals, and endodontic treatment is the most frequent subject of these complaints. These figures can be explained by the fact that endodontics is a complex procedure influenced by various biological, technical, and anatomical factors. As a result, complications may arise during or after treatment, which must be properly understood and managed.

Iatrogenic incidents commonly occur during root canal treatments and can significantly compromise treatment quality. These errors may lead to serious health consequences for patients, potentially worsening existing conditions.

Qutieshat defines consequences as the effect on the final outcome resulting from an error during treatment. While some errors can be corrected, others negatively impact the overall quality of the treatment. The author categorizes the consequences into three levels:

1. Lesions in the Periapical Area: This includes teeth with overfilling (overextension), which may cause complications at the apex such as inflammation, foreign body reactions, or delayed healing.
2. Tooth at Risk of Future Complications: These are cases where errors do not immediately compromise the tooth but may lead to future issues. For example, underfilled (underextended) root canals may allow bacterial leakage and subsequent infection³.
3. Errors Requiring Referral to a Specialist: In more severe cases, correction of the iatrogenic incident requires retreatment, surgical intervention, or even extraction of the affected tooth.

The consequences of iatrogenic errors often unfold as a cascade of events. For instance, if the working length is inaccurately determined, it can lead to inadequate instrumentation and consequently poor obturation, causing pain, discomfort, and residual tissue inflammation. Additionally, this increases the risk of further iatrogenic complications such as ledge formation, root perforation, apical transportation, and ultimately, treatment failure.

4. Conclusion

Despite technological advancements, iatrogenic incidents in endodontics remain a significant challenge in clinical practice. Complications such as root perforations, instrument fractures, and improper obturation continue to occur frequently. Although tools like dental operating microscopes and cone-beam computed tomography (CBCT) have improved diagnostic accuracy and treatment precision, the clinician's expertise remains crucial.

Continuous professional development, strict adherence to evidence-based protocols, and the appropriate use of advanced technology are essential for minimizing risks. Detailed treatment planning, careful selection of instruments, and meticulous irrigation techniques play a key role in preventing complications.

Implementing these preventive measures can significantly reduce iatrogenic incidents, thereby improving the prognosis and success rate of endodontic treatments. Moreover, collaboration between clinicians, industry, and academia is vital for advancing technologies and materials that enhance clinical outcomes and promote safer dental care.

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