Clinical use of CBCT in endodontics: a case series following ese position statement

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Abstract

In the last decade, cone-beam computed tomography (CBCT) has emerged as a game changer in endodontics, significantly enhancing clinicians' diagnostic and treatment capabilities. The ability to assess the internal and external morphology of teeth and surrounding tissues in three dimensions has redefined diagnostic accuracy, treatment planning, and operative procedures (including guided endodontics), improving quality and clinical outcomes. Despite its numerous advantages, the use of CBCT must be justified based on clinical necessity and balanced against radiation exposure. Therefore, the European Society of Endodontology (ESE) has published a position statement on the clinical use of CBCT to give precise recommendations concerning the clinical cases in which it should be used. The present article aims to analyze the content of the ESE position statement by showing, through clinical cases, the benefits of CBCT in everyday practice.

Key words. CBCT, endodontics, radiography.

Introduction

In the last decade, cone-beam computed tomography (CBCT) has emerged as a transformative imaging modality in endodontics, significantly enhancing clinicians' diagnostic and treatment capabilities (1-6). Unlike conventional two-dimensional (2D) radiography, CBCT provides three-dimensional (3D) visualization of dental and maxillofacial structures. This advancement allows endodontists to obtain detailed and accurate images of tooth and canal anatomy, periapical tissues, and surrounding structures, which is particularly important in complex endodontic cases. The ability to assess teeth's internal and external morphology in three dimensions has redefined diagnostic accuracy, proper treatment planning, and shaping procedures, thereby improving clinical outcomes. Using CBCT allows clinicians to visualize all the complex root canal systems, thus preventing them from missing any canals, even in unusual anatomy. Moreover, allowing a 3D visualization of canal trajectories provides for the determination of their influence on instrumentation stress, thus reducing the risk of intracanal failure of endodontic instruments.
Many articles have been published recently on the importance of CBCT in endodontics, and all of them agree on the fact that one of the most critical applications surely is in

the diagnosis of periapical pathologies, which may not always be visible on standard periapical radiographs (7-15). This happens because traditional 2D imaging can be limited by anatomical superimposition and geometric distortion, which can obscure small lesions or complex anatomical features. CBCT, by contrast, eliminates these issues by providing cross-sectional and volumetric images, enabling clinicians to detect many pathologies like periapical lesions, root fractures, and resorptions with significantly higher accuracy. Early and precise detection of these conditions allows for timely and targeted intervention, reducing the risk of complications and improving the prognosis of endodontic treatments of such complex cases.

Moreover, CBCT is vital in treatment planning and intraoperative navigation (16-21). Understanding the intricate anatomy of root canal systems is essential for practical shaping, debridement, and obturation. CBCT enables clinicians to identify variations such as extra canals, calcifications, or unusual curvatures that may go unnoticed with traditional imaging. This is particularly important in teeth with complex anatomies, such as maxillary molars or mandibular premolars, where missed canals can lead to persistent infection and treatment failure. By providing a 3D visualization of the root canal system and canal trajectories, CBCT helps clinicians to execute more efficient and safer treatments, reducing the incidence of iatrogenic errors such as perforations or instrument separation.

CBCT is also valuable in assessing treatment outcomes and post-operative complications (22-26). It allows clinicians to evaluate the healing of periapical lesions and the integrity of root fillings with greater confidence than 2D radiographs. For instance, it can reveal persistent periapical radiolucency that may indicate treatment failure or help locate previously missed anatomy during retreatment. In cases of dental trauma, CBCT provides critical information regarding cracks, root fractures, alveolar bone damage, and displacement of tooth structures. All this data is often difficult to obtain with traditional imaging. This comprehensive assessment capability supports better decision-making in both initial and follow-up care. Moreover, CBCT can also be a useful tool for research, as shown by various studies made by the authors, both for clinical and experimental research. (27-30)

Despite its numerous advantages, the use of CBCT must be justified based on clinical necessity and balanced against radiation exposure (31-33), ideally following the ALARA Concept (As Low As Reasonably Acceptable). Although CBCT exposes patients to higher radiation doses than conventional radiographs, its doses are still significantly lower than those associated with medical CT scans. Moreover, in endodontics, many cases can be successfully treated with a low Field of view (5x5 FOV), significantly reducing radiation exposure. To provide advice for the use of CBCT, the American Association of Endodontists (AAE) and the American Academy of Oral and Maxillofacial Radiology (AAOMR) recommend the use of CBCT in cases where conventional imaging fails to provide sufficient diagnostic information or when complex anatomy or pathology is suspected. When used judiciously and appropriately, the diagnostic benefits of CBCT far outweigh the risks, particularly in complex or ambiguous cases where conventional imaging may fall short.

Following this trend, the European Society of Endodontology (ESE) has published a position statement on the clinical use of CBCT to give precise recommendations on which clinical cases should be used (33). Table 1 shows the clinical situation where CBCT is suggested, defining 8 bullet points. The present article aims to analyze the content of the ESE position statement by showing clinical cases in which the clinical use of CBCT has been suggested, aiming to show the benefits of the technology in everyday practice.

Cases discussion

The first bullet point described by the ESE position statement (Table 1) detects radiographic signs of periapical pathosis when the signs and symptoms are nonspecific and plain film imaging is inconclusive.

Table 1. ESE position statement. use of CBCT for :

1. detection of radiographic signs of periapical pathosis when the signs and/or symptoms are non-specific and plain film imaging is inconclusive;
2. assessment and/or management of dento-alveolar trauma, which may noi be fully appreciated with conventional radiographs;
3. appreciation of anatomically complex root canal systems prior to endodontic
4. management (e.g dens invaginatus);
5. nonsurgìcal re• treatment of cases with possible untreated canals and/or previous treatment complications (e.g. perforations);
6. assessment and/or management of root resorption, which clinically appears to be potentìally amenable to treatment;
7. presurgical assessment prior to complex periradicular surgery (e.g. larga periapical
8. lesions in posterior teeth, and the evaluation of their proximity to adjacent relevant anatomica! structures);
9. identification of the spatial location of extensìvely obliterated canals, also taking into
10. account the possibilities of guided endodontics;
11. detection of periradicular bone (secondary) changes indicative of root fractures, when clinica! examination and conventional imaging modalities are not conclusive.

In the case shown in Figure 1a, the patient reported pain from chewing on two previously treated teeth. The two-dimensional radiograph was not conclusive because it could not clearly show if any lesion was present, due to anatomical superimposition. Such a possibility is relatively common in the molar area and upper arch. Therefore, A small FOV CBCT was taken and the 3D image (Fig. 1 b) clearly showed two big lesions of endodontic origin, one in the molar and one in the premolar. It is exciting to note that despite the significant lesions, it was impossible to detect them clearly with a traditional 2D radiograph.

Small endodontic lesions may not be easily detected

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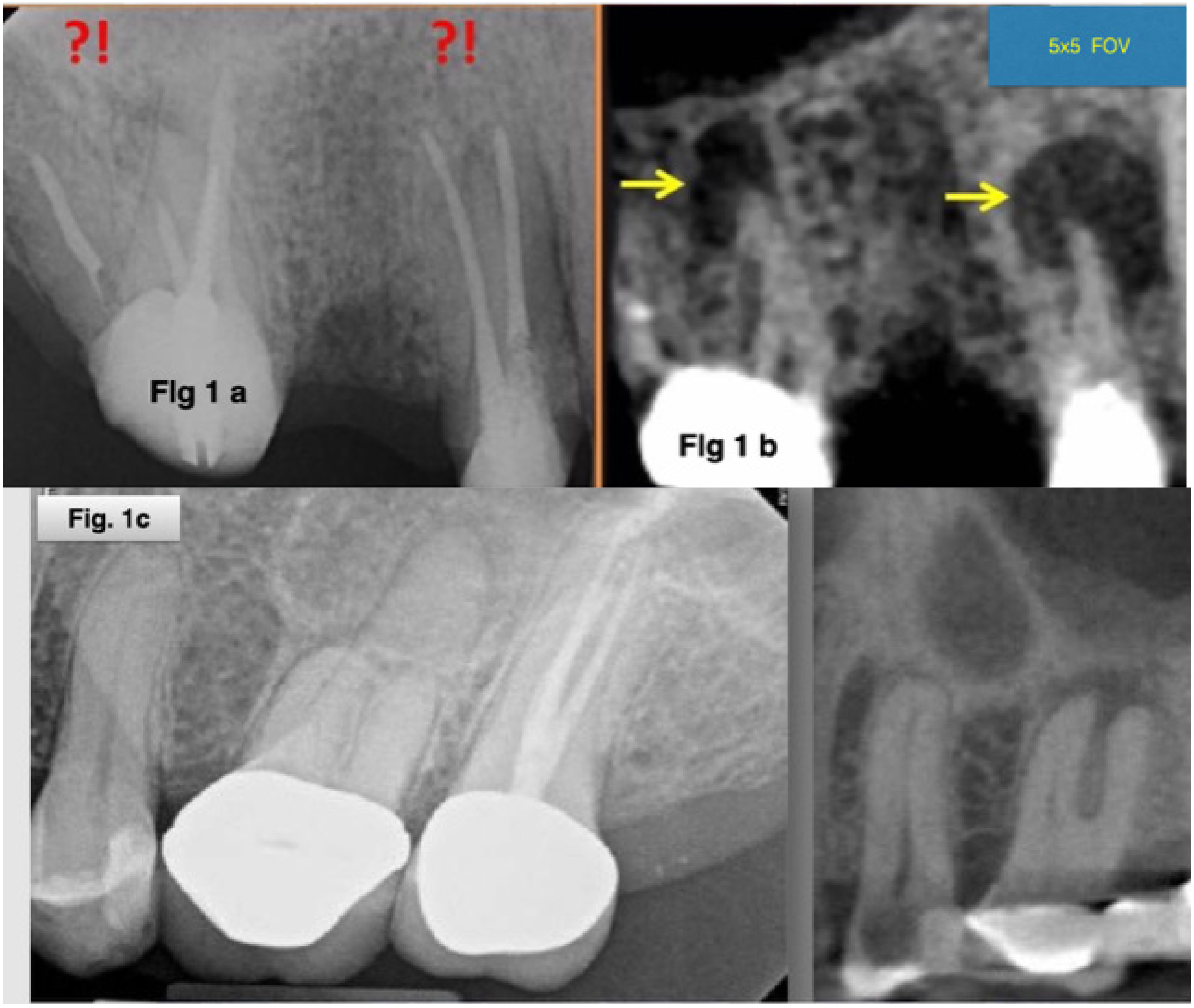

Figure 1. Initial small lesions are more difficult to be found, since they appears in traditional X rays only cortical bone has been reached

due to the superimposition of cortical bone. Figure 1c also explains why this happens. Initial small lesions are more difficult to visualize since they are shown by traditional 2D radiographs only when the cortical bone has been reached. Therefore, there is a much higher possibility when using CBCT to detect small lesions that cannot be seen with two-dimensional radiographs (approximately 20% of cases, which is a very significant percentage in clinical practice).

The second bullet point is assessing and managing dental alveolar trauma, which may not be fully appreciated with a conventional radiograph. In the case shown by Figure 2a, there is a lower molar root canal treatment, which appears to be very well done in a two-dimensional radiograph, even if there is a persisting apical radiolucency and pain on chewing. The CBCT exam (Fig. 2 b) showed a coronal crack not detected by the initial radiograph. When a crack or a fracture is present, it communicates between the oral cavity and the tooth/periradicular tissues. Such a pathway allows bacteria from the oral cavity to reach the inside of the tooth and the bone, continuously bringing new contamination. No surprise that this superinfection may not allow healing or may induce a new infection in the endodontically treated tooth, because our endodontic procedures (even if they may look good radiographically) are never fully able to clean, disinfect, and fill 100% of the endodontic space three-dimensionally.

In the case shown by Figure 2c, a much bigger lesion is present in the furcation area of a lower molar with an inferior endodontic treatment. In such a case, the failure is probably unrelated to the wrong treatment. Clinicians should ask themselves why the previous dentist did not perform the endodontic therapy correctly. Did he find some unusual complex anatomy, or was it an iatrogenic error? Taking a CBCT scan (Figure 2d/e) allows proper understanding, showing a clear fracture that could also be related to a non-correct access cavity or restorations, with a split root. It's no surprise that such significant damage, which creates a big communication, can result in a huge lesion involving the furcation and the coronal part of the root, as CBCT clearly shows. It is interesting to note how lesions usually appear much bigger in 3D than in 2D.

The third bullet point is appreciating the anatomical complex root canal system before endodontics management (e.g., dens invaginatus). Figure 3a shows a failure case (persistent pain) after a root

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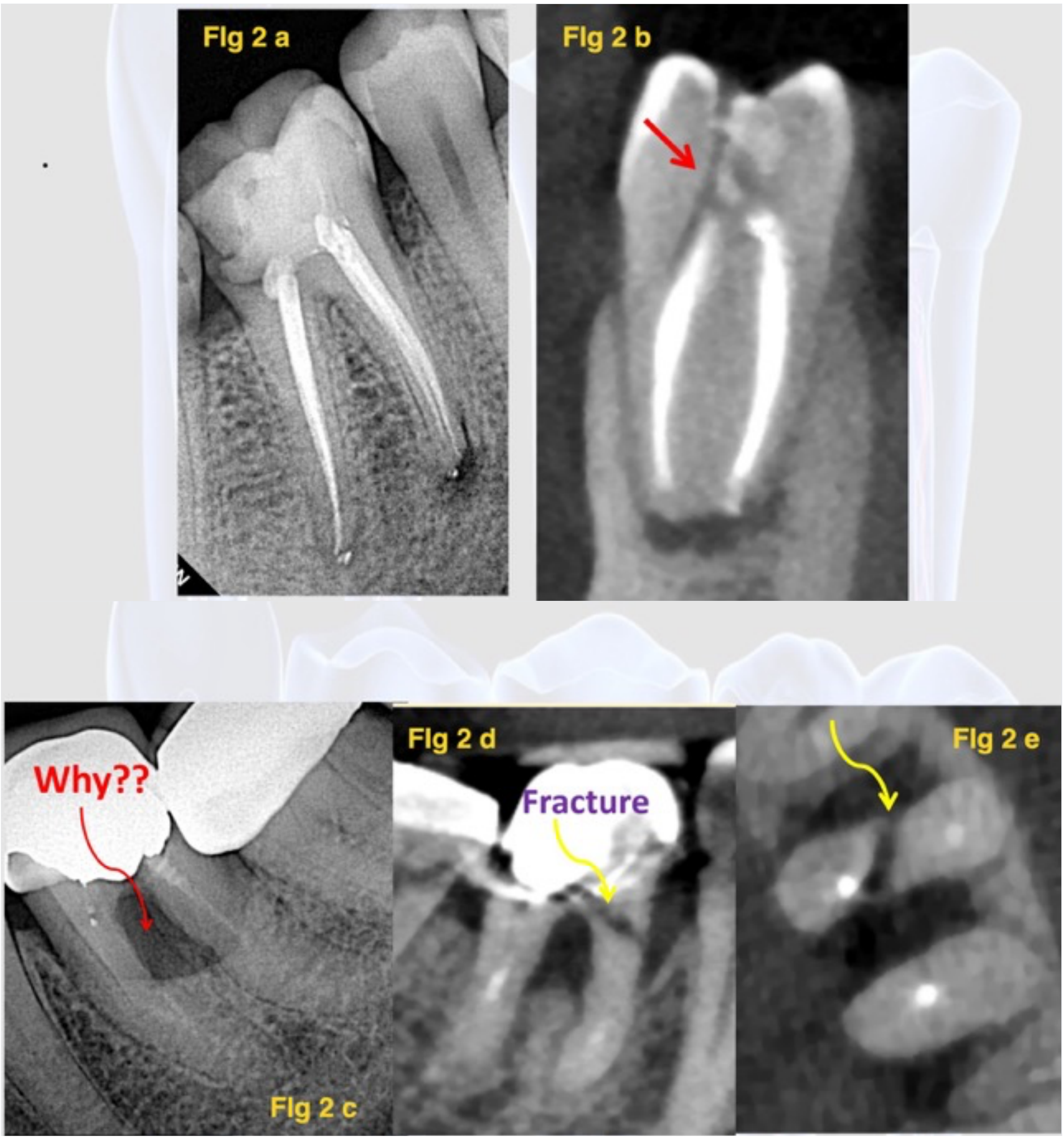

Figure 2.

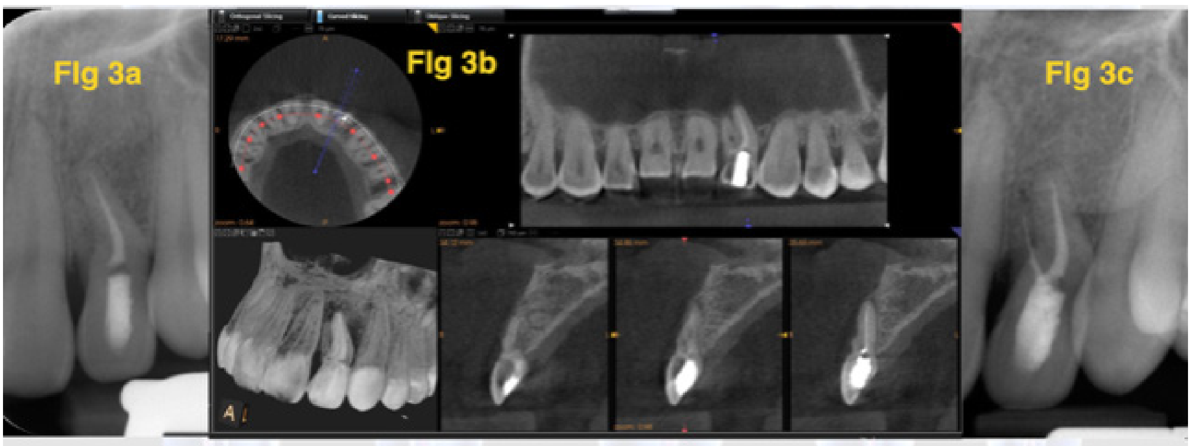

Figure 3.

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Sinus
Flg 4 a
Flg 4 b
Missed DB canal
Flg 4 c
Fig 4d
??
Lesion!!
MB2
Fig. 4f
P1
P2
Fig. 4g
P1
P2
Fig. 4h
Fig. 4h
Missed
treatment
Fig. 4i
Fig. 4f

Figure 4.

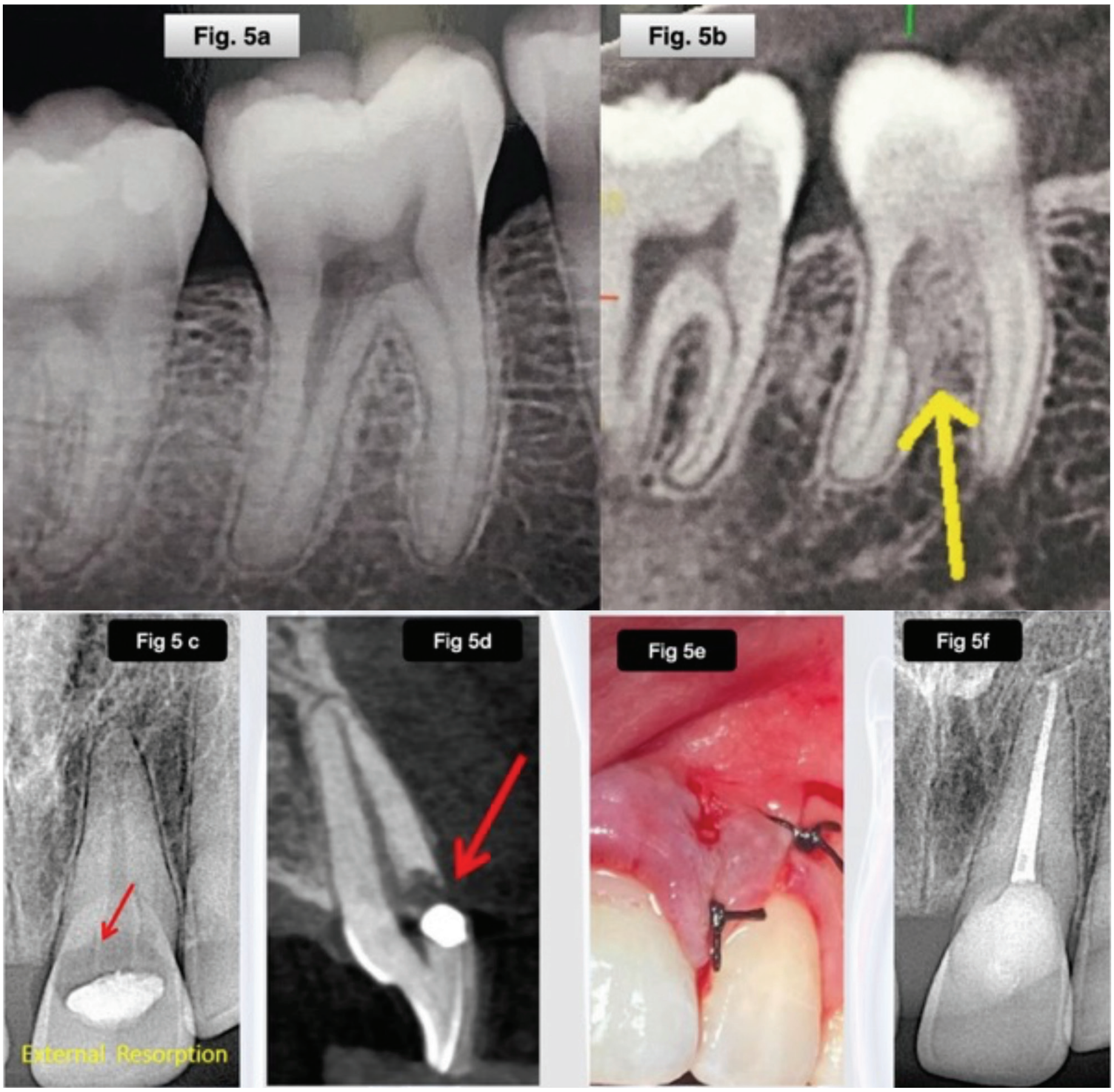

Figure 5.

canal treatment of an upper lateral incisor, even if the treatment appears properly performed. In the periapical radiograph, it is impossible to determine the cause of such a failure. A CBCT scan (Fig. 3 b) showed a missing canal because of this unusual anatomy (dens invaginatus). This missing canal was very complex to treat because the access cavity was designed differently. Consequently, it was not easy to locate the second canal and then properly shape, clean and obturate it (Fig. 3c) Despite these difficulties and the fact that the overall quality of the therapy of the missing canal is not as good as the central canal, the treatment was good enough to promote healing and tooth became asymptomatic.

The fourth bullet point is the treatment of cases with possible untreated canals or previous treatment complications like perforations. Untreated canals are one of the leading causes of endodontic failure. When suspecting this clinical situation, CBCT should be used, since it can easily solve the diagnostic problem by showing the real anatomy. Figure 4a shows a case with a sinus tract and an endodontic lesion in an upper premolar. The 2d radiograph with a gutta-percha cone inside the sinus tract (Fig. 4 b) can show which tooth is responsible for the pathology, because in some cases, the sinus tract may be slightly distant from the infected tooth. However, it does not clarify the quality of the previous treatment or if a missed canal/ unusual anatomy is present. In the present case, CBCT (Fig. 4c) shows a missed distal buccal canal and the corresponding endodontic lesion.

The most common missed canal is MB2 in upper first molar. When clinicians are not able to find MB2 a CBCT scan should be taken in order to check if MB2 is present or not. The scan will also allow to find the orifice more easily, since it can show if it is located more palatal or deeper (more apically) due to a partial pulp calcification.

Figure 4d show a case when a missed M2 was responsible for a failure of a previous treatment,

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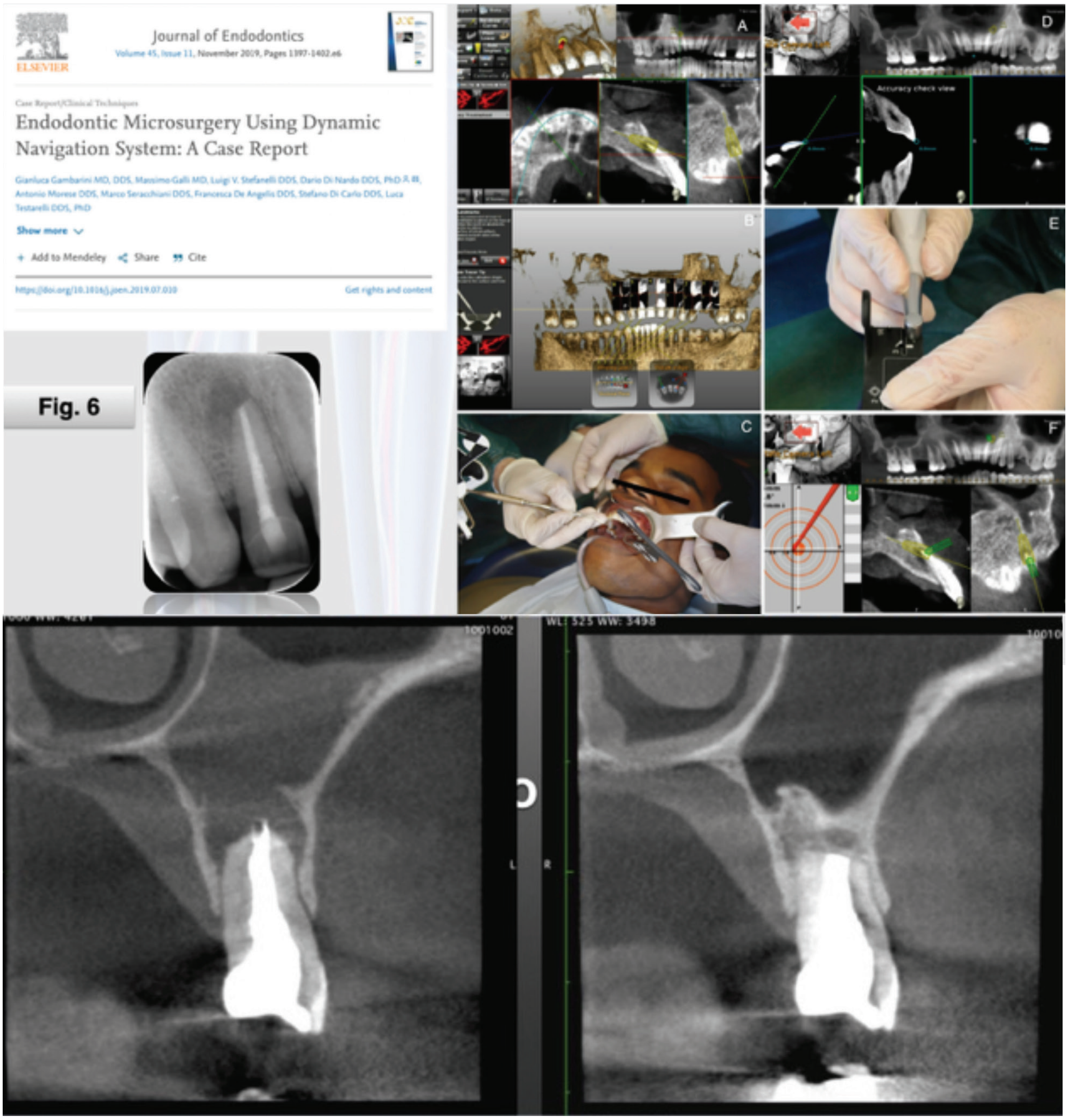

Figure 6.

showing how CBCT allowed proper visualization of its presence and the presence of a lesion.

In some retreatment cases failures may depend on two factors: inappropriate treatment of the visible canals and a missed canal. Both factors may lead to a negative outcome. Therefore when performing orthograde retreatment attention should be payed not only on retreating the visible canals with a proper technique but also on checking if unusual anatomy is present. In the case shown by Fig. 4f the clinical problem was not only to make a proper treatment of the canals that were previously treated but also to be sure that all the canals were found, CBCT helped visualizing a quite unusual there was a double canal in the palatal root of an upper molar (fig4g). In such cases if clinicians do not treat all canals it is very unlikely to have a successful root canal treatment. The correct use of CBCT allowed proper orthograde retreatment of the case (Fig. 4h).

CBCT has also allowed clinician to visualize a rather common iatrogenic error, which is currently defined as "missed treatment" . More precisely, the mistake is not missing a canal but missing proper shaping cleaning and obturation of the endodontic space three-dimensionally. In such cases, as shown by fig,4h the root canal therapy looks fine but there is a small lesion at the apex. A common reason why such a lesion is present is that there are still infected debris left inside the root canal which maintain the infection. Such debris appears as voids (Fig. 4i) showing a poor quality of canal debridement and could maintain a persistent infection inside the root canal system, thus resulting in a negative outcome. Even if these cases are not easy to be diagnosed without a CBCT, their treatment is relatively easy. It requires more careful

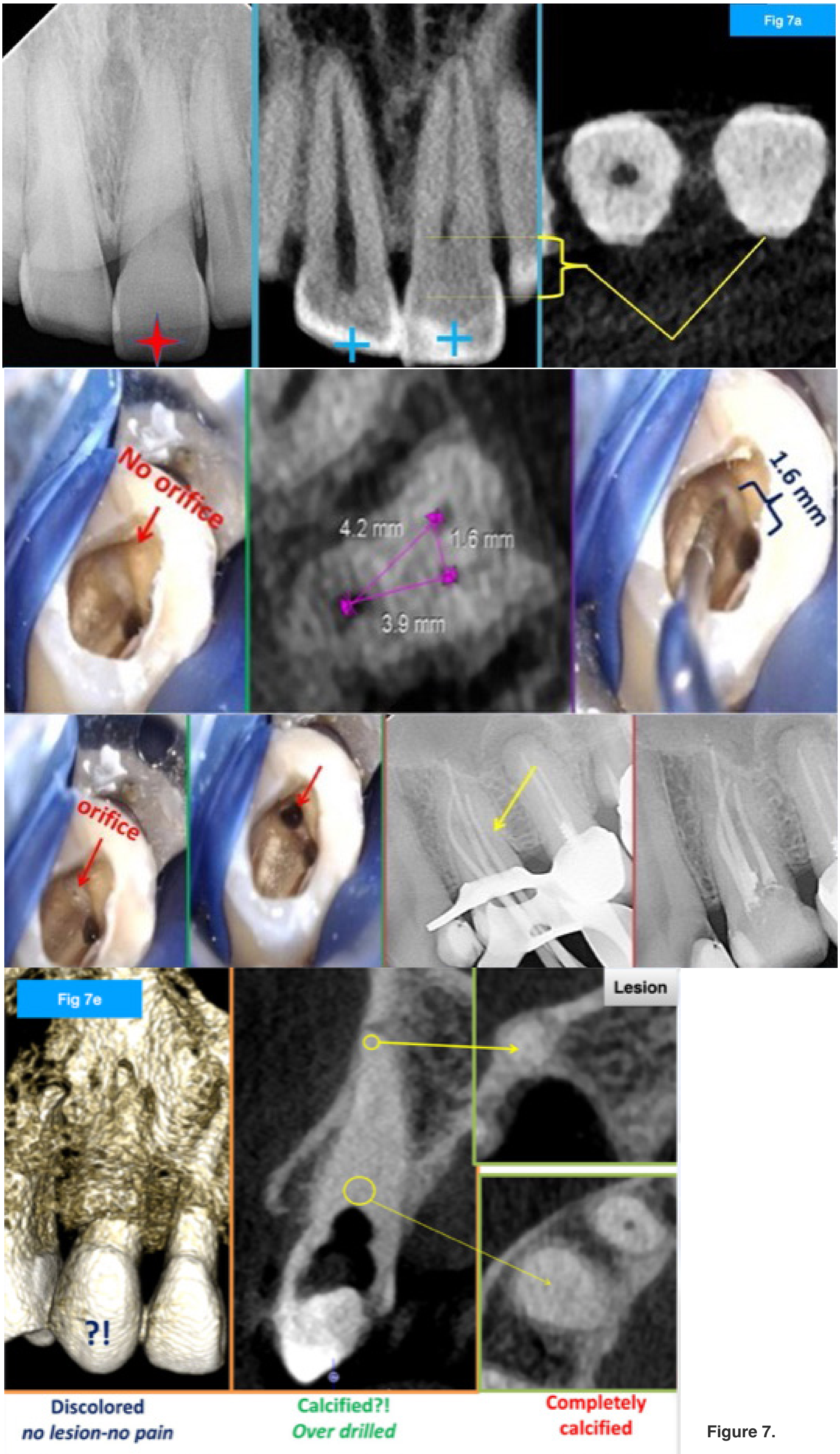

Figure 7.

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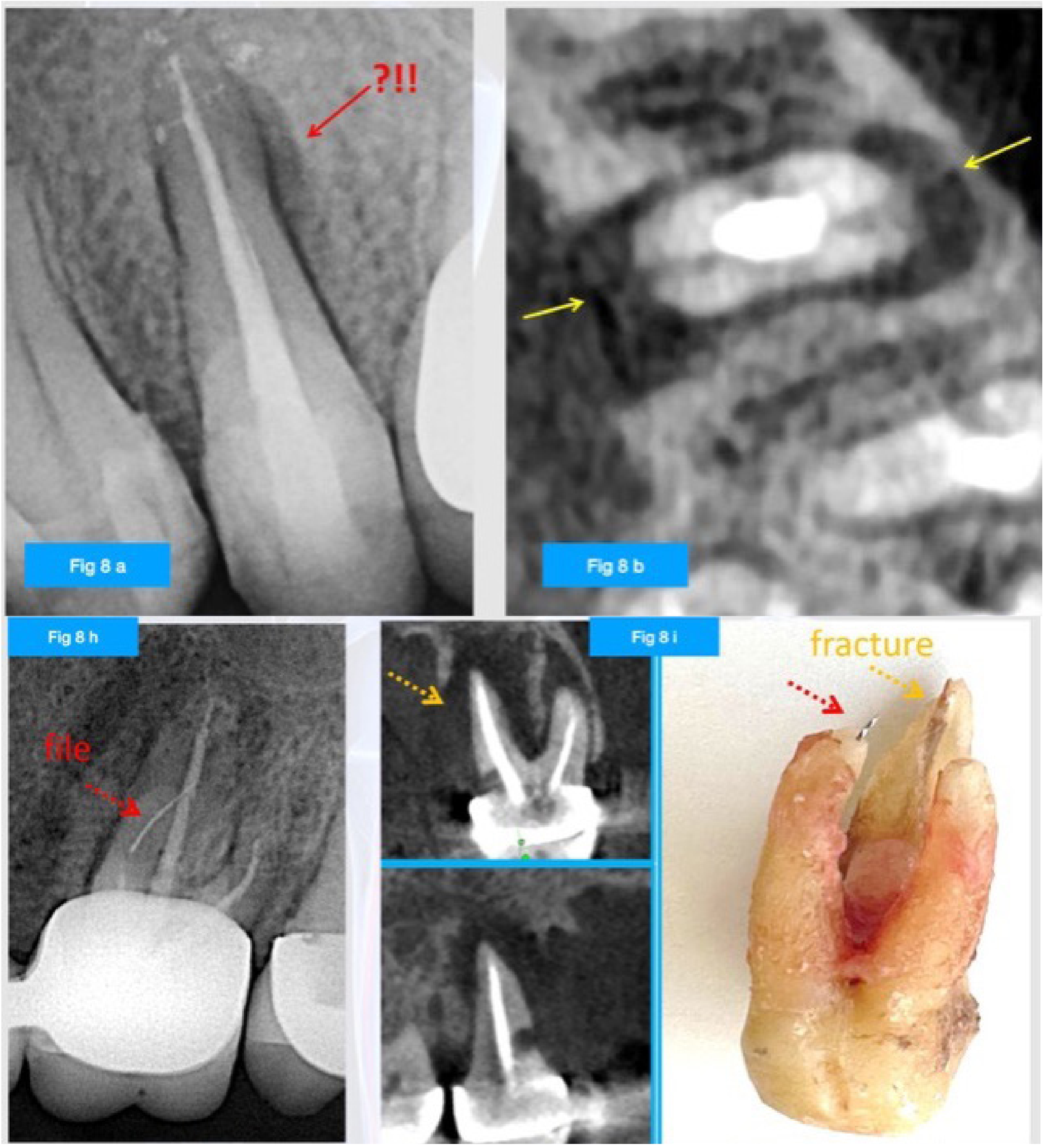

Figure 8.

three-dimensional shaping, cleaning and filling of the endodontic space after removing the original obturating material.

Bullet number five is assessment and management of root resorption which clinical appears to be potentially amenable to treatment. Root resorptions can be often visualized with traditional 2D radiography, but not in all cases. Moreover it is usually very difficult to determine the real extension of the resorption and consequently make a proper treatment plan. Figure 5a shows a symptomatic case of a lower first molar in which 2d image which is not conclusive. By looking more carefully clinicians could suspect that there is something wrong in the distal root, related to a coronal radiolucency bigger than the canal. However only by taking a CBCT scan (fig 5b) clinicians can make a proper treatment plan, clearly visualizing the presence and the extension of internal and external resorption that is highly damaging the distal root.

When dealing with resorption case clinicians need to evaluate carefully the extension of the process, its relationship with bone and periodontal tissue, and how complex the multidisciplinary therapy can be. Such an evaluation cannot be done with a 2d radiograph as shown by Fig. 5c. It need a CBCT scan (Fig. 5d). By correctly evaluating all information provided by CBCT clinician can choose the correct treatment plan, which is often multidisciplinary (Fig. 5e) with a combined endodontic and periodontal treatment to clean and seal the resorption, The present case was successfully managed because the dentist knew very well what to do and how to do. From the very beginning (Fig. 5f).

Another bullet is the presurgical assessment prior to complex periradicular surgery for example large apical lesion in posterior teeth and the evaluation of their proximity to additional relevant anatomical structures. The use of CBCT in endodontic surgery is a highly adopted procedure also because in some cases CBCT is useful for guided surgical therapy using static and dynamic guides. Figure 6 shows an example of the first documented endodontic microsurgery using dynamic navigation system, Such innovations enhance the possibilities of surgically treating endodontic lesions in a more precise and less invasive way.

As shown by figure 6b CBCT can be useful to evaluate healing process in the surgically treated tooth and in the adjacent tissues, including maxillary sinus.

Bullet point number seven is the identification of the spatial location of extensively obliterated canals, also taking account the possibility of guided endodontics . CBCT can be a great clinical aid because in the majority of cases with calcifications clinicians don't have the proper visualization of how relevant the pathology is in three dimensions. Once again superimposition of dentine and bone usually does not allow a clear visualization in 2d (fig 7a) , but using a CBCT allows clinicians to know exactly if the canal is calcified, to which extent is the calcified. These information are needed for a proper treatment planning and to assess the difficulty of the procedure. The deeper the calcification, the more complete the calcification process the more complex is the case. In case shown by figure 7 CBCT showed that the canal at a certain depth was no longer calcified, so it could be reached using burs and instrument with free hand technique (by knowing the depth of the calcification and the angulation of the root) or preferably with guided endodontic therapy.

CBCT helps manage these complex cases by providing relevant clinical information on the location of orifices. As shown by case 7b, very complex calcified cases can be successfully treated if clinicians know the calcification's extension and the orifices' location. Once CBCT has provided the information, clinicians can start finding the orifice with the help of an operative microscope. Light and magnification are crucial tools during the procedure,

On the other hand, if CBCT shows (Fig. 7a) a case when the canal is obliterated, clinicians should avoid weakening the crown in a useless attempt to find a calcified canal. They should understand the problem from the beginning and try to solve it in another way, maybe with surgery (13:33) and leaving the crown intact.

The last bullet point detects the periapical bone secondary changes indicative of root fracture when clinical examination and conventional imaging modalities are inconclusive. In clinical practice, there are cases, as shown by Figure 8a, in which we may suspect a root fracture due to the unusual pattern of the periradicular radiolucency. However, it is not easy to decide to extract a tooth previously endodontically treated without being sure it is no longer retreatable. Only by using a CBCT scan (Figure 8b) can clinicians and patients easily visualize the presence of a fracture, which negatively affects the prognosis.

In most cases, CBCT allows us to see the fracture or even the crack, as shown in Figure 8c.

However, in cases where the 3D image doesn't show them clearly, an unusual bone lesion can be a relevant factor determining an indirect diagnosis, as indicated by Figure 8f. The microscopic image confirmed the diagnosis in the present case, as shown in Figure 8g.

Root fracture is a dramatic event that leads to tooth loss and consequently is mandatory to diagnose it properly in complex cases, where a 2D image could also suggest an orthograde retreatment with file removal (surgical or nonsurgical). In the case shown by Figure 8h, CBCT allowed for the visualization of a fracture and prevented a wrong treatment plan, losing the time to disassemble the crown and start an unnecessary treatment for the patient.

Conclusions

In conclusion, authors believe that CBCT represents a paradigm shift in endodontics, offering unparalleled visualization of dental anatomy and pathology. The present article presents a series of clinical cases to show how CBCT use enhances diagnostic accuracy, improves treatment planning, facilitates clinical procedures, and better monitors treatment outcomes. The ESE Position statement suggested that while it is not a replacement for traditional radiographs in all cases, CBCT can be a powerful adjunct tool in the endodontic arsenal, particularly in the complex cases suggested by ESE. As technology continues to evolve in the endodontic field (34-39), integrating CBCT into endodontic practice promises to elevate the standard of care further, resulting in more predictable, successful outcomes.

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