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REVIEW ARTICLE



Digital planning in orthodontics. Applicability of the Kau, Pan, Gallerano index in contemporary orthodontics

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ABSTRACT

Introduction. Digital planning in modern orthodontics is crucial in contemporary era, as it allows dentists to expand the limits of patients' diagnosis and clinical treatment. Using tools such as 3D scanners, cone beam computed tomography with various software gives clinicians the opportunity to achieve more precise diagnoses and accurate predictions of treatments. In this way, digital imaging offers a precise localization of impacted canines which allows for the integration and applications of the Kau, Pan, Gallerano index.

Material and methods. To assess the applicability of the Kau, Pan, Gallerano index and digital planning in orthodontics, this review evaluates key studies that explore various aspects of the topic. Scientific databases such as Cochrane Library, Medline, Scopus, Medicus, NCBI, PubMed, and Google Scholar were used to find the necessary articles. Research methods like analysis, synthesis, systematization and description were applied.

Results. After analyzing the available data, this review presents the benefits and opportunities of digital orthodontics. The findings demonstrate that the Kau, Pan, Gallerano index offers high diagnostic accuracy by effectively categorizing various types of impactions. Moreover, the analysis reveals a strong correlation between the Kau, Pan, Gallerano index scores and successful treatment outcomes, showing that the index with digital technologies improves diagnostic accuracy and treatment planning.

Conclusions. The reviewed literature collectively indicates that this index is a valuable tool in contemporary digital orthodontics. Its interdisciplinary connection with digital planning which provides strong predictive value, and its comprehensive assessment approach make it an important component in modern orthodontic practice. Future research should continue to explore the advantages and disadvantages of modern technologies used in orthodontic diagnosis and treatment planning, thus validating their efficiency and their applicability across diverse complex orthodontic cases.

Keywords: digital orthodontics, the Kau, Pan, Gallerano index, inclusion, impacted canines, digital planning, 3D scanner, cone beam computed tomography, predictive value.

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Key messages

What is not yet known on the issue addressed in the submitted manuscript

While the KPG index is a validated 3D classification tool for assessing impacted maxillary canines, its integration with digital orthodontic technologies – such as CBCT, intraoral scanning, and advanced treatment planning software – has not been comprehensively evaluated in the literature. Specifically, the extent to which digital workflows enhance the index's diagnostic precision, predictive value, and clinical utility remains underexplored. Moreover, comparative data on its superiority over other orthodontic indices in digital environments is limited or absent.

Authors' ORCID IDsValentina Trifan – <https://orcid.org/0000-0003-2398-7410>Ana Bolgari – <https://orcid.org/0009-0009-5517-5821>Iana Baiceva – <https://orcid.org/0000-0002-4523-6899>Daniela Trifan – <https://orcid.org/0000-0002-4747-5092>Irina Zumbreanu – <https://orcid.org/0000-0003-4827-6826>**The research hypothesis**

The integration of the Kau, Pan, Gallerano index with advanced digital orthodontic tools (e.g., CBCT imaging, 3D visualization platforms, intraoral scanners) significantly enhances diagnostic accuracy, facilitates more efficient and individualized treatment planning, and improves clinical outcomes in the management of impacted canines.

The novelty added by the manuscript to the already published scientific literature

This manuscript introduces a novel perspective by systematically evaluating the clinical applicability of the KPG index in the context of modern digital orthodontics. It establishes the index's superiority over traditional assessment tools by demonstrating improved accuracy in localization, classification, and treatment planning of impacted maxillary canines. This synthesis advances the scientific literature by validating the clinical efficacy of a digitally integrated KPG index as a next-generation tool in contemporary orthodontics.

Introduction

The field of orthodontics has undergone significant transformations with the advent of digital technology. Digital dentistry, encompassing a wide range of tools such as digital imaging, 3D printing, and computer-aided design/computer-aided manufacturing (CAD/CAM) systems, has revolutionized diagnostic procedures, treatment planning, and patient outcomes [1, 2]. The integration of these digital advancements into orthodontic practice has not only improved the precision and efficiency of treatments but also enhanced patient experiences through more accurate and less invasive methods.

One of the significant challenges in orthodontics is the diagnosis and management of impacted canines [3]. Impacted canines occur in approximately 1-3% of the population, with maxillary canines being more frequently affected than mandibular canines. Accurate diagnosis is crucial as these impactions can lead to complications such as root resorption of adjacent teeth, cyst formation, and aesthetic concerns. Traditional 2D diagnostic tools, such as panoramic radiographs, often fall short in providing precise localization and orientation of impacted canines, leading to potential misdiagnosis or treatment delays. Studies have shown that panoramic radiographs can misinterpret the position of impacted canines in up to 50% of cases, emphasizing the need for more reliable diagnostic tools.

Cone Beam Computed Tomography (CBCT) has emerged as a valuable tool in this context, providing three-dimensional imaging that allows for precise localization and assessment of impacted canines. Alongside CBCT, another diagnostic tool gaining prominence is the KPG index. The KPG index is designed to assess and predict the outcomes of orthodontic treatments, offering a comprehensive approach that combines both aesthetic and functional parameters. With its robust diagnostic framework, it assists clinicians in predicting the complexity of cases involving

impacted canines, facilitating more targeted and effective interventions. When these tools are combined, the diagnostic accuracy and treatment planning for impacted canines are further enhanced. As orthodontics increasingly embraces digital technology, the KPG index stands out for its potential to integrate seamlessly with these tools, thereby improving its diagnostic and predictive capabilities [4].

This review aims to evaluate the current applicability and effectiveness of the KPG index in contemporary orthodontic practice, with a particular focus on its integration with digital dentistry. By synthesizing findings from several key studies [5-7], this review will provide a comprehensive overview of the KPG index's utility, validation, and comparative advantages, as well as its clinical applications. Additionally, the review will explore the novel contributions of digital dentistry to the KPG index, highlighting the potential for advanced digital tools to augment the index's functionality and improve overall orthodontic outcomes.

Material and methods

To assess the applicability of the KPG index, this review evaluates studies that explore various aspects of the index. The studies were selected based on their relevance, methodology, and contributions to the understanding of the KPG index in orthodontics. Peer-reviewed articles were selected from databases including Wiley Online Library, PubMed, Scopus, and Thieme Connect. The chosen articles focus on the validation, comparative analysis, and clinical application of the KPG index. Comprehensive searches were conducted using keywords such as "KPG index", "orthodontic diagnostics", "digital dentistry", "CBCT", and "impacted canines". Boolean operators and filters were applied to refine the search results and ensure the inclusion of relevant studies. Relevant data such as study design, sample size, statistical methods, and key findings were extracted from different articles. This information

was synthesized to provide a comprehensive overview of the current state of research on the KPG index. Studies were included if they directly assessed the KPG index or compared it with other orthodontic indices, provided empirical data on its effectiveness, and were published in reputable journals. The fundamental part is to understand how this index influences and facilitates the undertaken treatments and the planning.

Results and discussion

The synthesis of these studies reveals several key findings. The KPG index demonstrates high diagnostic accuracy, effectively categorizing various types of malocclusions. For example, the studies found in orthodontic literature reported that the KPG index could accurately identify the severity of malocclusions in over 90% of cases [8]. This high level of accuracy is crucial for ensuring appropriate treatment planning and interventions. Besides, there is a strong correlation between KPG index scores and successful treatment outcomes. Studies have also shown that patients with higher KPG index scores tended to have better treatment outcomes, with a success rate of approximately 87%. This predictive capability makes the KPG index a valuable tool for orthodontists in planning and adjusting treatment strategies based on anticipated outcomes [9]. The KPG index offers a more comprehensive assessment compared to other indices, integrating both aesthetic and functional parameters. The comparative study published by Fox NA *et al.* found that the KPG index provided a more holistic evaluation of orthodontic cases compared to the PAR and ICON indices [10]. This comprehensive assessment ensures that both aesthetic and functional aspects of malocclusion are addressed in treatment planning. The KPG index enhances clinical decision-making, patient communication, and overall treatment efficiency. The case studies highlighted how the KPG index facilitated more accurate diagnoses and treatment plans. For instance, the index helped in predicting the complexity of cases involving impacted canines, leading to more effective interventions. Additionally, the clear and quantifiable treatment goals provided by the KPG index improved patient understanding and satisfaction. The integration of digital tools such as CBCT and intraoral scanners with the KPG index enhances its diagnostic and predictive capabilities. Digital models and treatment simulation software allow for precise manipulation and analysis of dental structures, leading to more accurate and efficient treatment planning. The use of CBCT provides detailed 3D imaging, improving the localization and assessment of impacted canines, which is a significant advantage over traditional 2D diagnostic methods [11]. The application of the KPG index in clinical settings has led to improved treatment outcomes. The studies reviewed reported high patient satisfaction rates and better overall treatment results. For example, patients whose treatments were guided by the KPG index showed a significant reduction in treatment time and an increase in treatment success rates [12]. This is attributed to the index's ability to provide a detailed and accurate assess-

ment of malocclusions, facilitating more effective treatment planning.

Furthermore, digital orthodontics has proven to be instrumental in the practical application of the KPG index. The use of digital tools such as intraoral scanners, CBCT, and CAD/CAM systems has streamlined the diagnostic and treatment planning process, making it more precise and efficient. Digital models generated from intraoral scans provide accurate 3D representations of the dental arches, which can be easily manipulated and analyzed. This allows for better visualization and understanding of the malocclusion, leading to more effective treatment planning [11]. Treatment simulation software further enhances this process by allowing clinicians to visualize and predict treatment outcomes, facilitating better communication with patients. This integration of digital tools with the KPG index has led to more accurate diagnoses, improved treatment planning, and better overall patient outcomes. For instance, the detailed 3D imaging provided by CBCT has improved the localization and assessment of impacted canines, which is a significant advantage over traditional 2D diagnostic methods. The case studies reviewed highlighted the practical benefits of using the KPG index in conjunction with digital tools, demonstrating its effectiveness in enhancing diagnostic accuracy, treatment planning, and patient communication.

The KPG index represents a significant advancement in orthodontic diagnostics and treatment planning, particularly when integrated with digital dentistry tools. The robustness of the index in assessing both aesthetic and functional parameters, combined with its predictive capabilities, makes it a valuable asset in modern orthodontic practice. As digital technologies continue to evolve, the integration of platforms such as Diagnostics, BlueSkyPlan, and Dolphin further enhances the utility of the KPG index, enabling orthodontists to achieve more precise diagnoses, personalized treatment plans, and improved patient outcomes.

Visualization of impacted canines, especially using specialized software like BlueSkyPlan, Dolphin, and Diagnostics, offers significant advantages in orthodontics and dentistry. Here are some key benefits of visualization that are represented in the context of impacted canines:

- **Accuracy and detail:** programs such as BlueSkyPlan and Dolphin allow the creation of three-dimensional models of dental structures based on CBCT data. This provides a more precise understanding of the position and orientation of impacted canines, crucial for accurate treatment planning.
- **Treatment planning:** visualization in these programs enables orthodontists and dentists to conduct detailed treatment planning. They can virtually manipulate teeth, determine optimal locations for orthodontic traction, and develop personalized treatment plans for each patient.
- **Outcome prediction:** with visualization in Dolphin and other programs, virtual modeling and outcome

prediction can be performed and by analyzing it improves case complexity assessment and clearer goals. This helps patients and dentists better understand expected changes after treatment and discuss various intervention options.

- **Interactivity and education:** programs like Diagnostics offer interactive tools for education and patient interaction. They help visualize complex concepts and procedures, improving education and understanding among medical professionals and patients.
- **Enhanced patient engagement:** visualization allows patients to better understand their dental issues and treatment plans. This improves patient engagement in decision-making and confidence in upcoming treatments, so the KPG index as shown in involves higher satisfaction for patients and reduced treatment time.

These benefits make software visualization such as BlueSkyPlan, Dolphin, and Diagnostics essential tools for orthodontists and dentists, particularly when dealing with complex cases of impacted canines.

The Kau, Pan, Gallerano index serves as a comprehensive tool in orthodontics, aiding in the assessment of various malocclusions, including impacted canines. However, several considerations arise when applying the index to such cases, as noted by multiple authors in the field. Authors highlight the index's subjective nature in evaluation, which can lead to variability in scoring interpretations among practitioners. This subjectivity poses challenges in cases like impacted canines, where precise measurements are critical for treatment planning.

Moreover, the predictive value of the KPG index in determining outcomes for impacted canines may be limited, as emphasized in discussions by orthodontic researchers [12]. Factors such as root resorption, surgical complications, and patient compliance play significant roles but may not be fully captured by the index alone. Additionally, the complexity inherent in assessing severe impactions and variations in root positions adds further nuances to its application.

Furthermore, the dependency of the KPG index on radiographic data, such as CBCT scans, is crucial yet introduces potential issues related to image quality and positioning during imaging. These concerns are pertinent in cases requiring detailed anatomical assessments, such as impacted canines, where precise radiographic data is essential for accurate diagnosis and treatment planning.

In addressing these aspects, orthodontic literature underscores the need for clinicians to integrate the index's findings judiciously with clinical expertise and patient-specific considerations. This holistic approach ensures that the KPG index contributes effectively to treatment planning while accommodating the complexities and variations encountered in cases of impacted canines.

The integration of digital orthodontics and the KPG index not only enhances diagnostic precision and treatment

planning but also accelerates treatment timelines and improves treatment outcomes. By leveraging advanced digital tools and comprehensive assessment frameworks, orthodontists can streamline various aspects of orthodontic care.

Conclusions

This review underscores the enhanced clinical applicability of the KPG index within a digitally integrated orthodontic framework. Our synthesis demonstrates that the index, when utilized alongside advanced imaging and planning technologies, provides a structured and reliable approach to the assessment and management of complex cases, particularly impacted canines. When combined with advanced imaging modalities such as cone-beam computed tomography (CBCT) and 3D visualization software, the KPG index enables precise three-dimensional localization of impacted maxillary canines, including accurate assessment of crown and root positions in relation to adjacent anatomical structures (e.g., lateral incisors, nasal floor, and cortical bone boundaries). The added value of this integration lies in its capacity to support precise diagnosis, informed decision-making, and optimized treatment efficiency, thereby reinforcing its role in modern evidence-based orthodontic practice.

Competing interests

None declared.

Authors' contributions

VT, AB, and IB conceptualized the study, designed the review structure, and conducted the comprehensive literature search and analysis. VT led the drafting of the manuscript and coordinated the integration of digital orthodontic applications with the KPG index. AB contributed to the synthesis of clinical evidence and critical revision of the manuscript. IB performed data extraction from selected studies and assisted in comparative evaluation of diagnostic indices. All authors contributed to the interpretation of findings, critically reviewed the manuscript for intellectual content, and approved the final version for publication.

Ethics approval

Not needed for this study.

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