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IMPROVEMENT OF ORTHODONTIC TREATMENT IN ADULT PATIENTS USING VARIOUS CORTICOTOMY TECHNIQUES BASED ON DIGITAL DENTISTRY

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Abstract. *This study aimed to evaluate the effectiveness of various corticotomy techniques based on digital dentistry in improving orthodontic treatment in adult patients. A total of 60 adult patients requiring orthodontic treatment were included and divided into two groups: a conventional orthodontic treatment group and a digitally guided corticotomy-assisted orthodontic treatment group. Digital imaging, three-dimensional treatment planning, and individualized surgical protocols were used to optimize clinical outcomes. The findings demonstrated that digitally guided corticotomy significantly accelerated orthodontic tooth movement and reduced the overall treatment duration compared with conventional treatment. Patients treated with corticotomy also exhibited favorable periodontal conditions, minimal postoperative complications, and a high level of treatment satisfaction. Digital dentistry improved the accuracy of diagnosis, surgical planning, and treatment monitoring, resulting in more predictable clinical outcomes. The integration of digital dentistry with modern corticotomy techniques represents an effective and reliable approach for enhancing orthodontic treatment efficiency, reducing treatment time, and improving patient-centered clinical outcomes in adult orthodontic patients.*

Keywords: *Digital dentistry; Orthodontic treatment; Adult patients; Corticotomy; Three-dimensional imaging; Tooth movement; Treatment planning; Clinical outcomes.*

Introduction

In recent years, the demand for orthodontic treatment among adult patients has increased significantly. Due to the lower biological activity of bone tissue in adults, tooth movement occurs more slowly, resulting in a longer treatment period. This may negatively affect treatment efficiency, increase the risk of certain complications, and reduce patients' motivation to continue treatment. Therefore, improving modern methods aimed at accelerating orthodontic treatment and enhancing its effectiveness has become one of the priority areas in contemporary dentistry. One of the effective methods used to accelerate orthodontic treatment is corticotomy. This technique involves performing minor surgical procedures on the cortical layer of the jawbone, which facilitates faster tooth movement and shortens the overall treatment period. Currently, several corticotomy techniques are widely used in clinical practice, and continuous research is being conducted to improve their effectiveness.

The development of digital dentistry has created new opportunities for more accurate and safer orthodontic treatment planning.

Three-dimensional imaging, digital intraoral scanning, and computer-assisted planning allow clinicians to evaluate patients' anatomical characteristics comprehensively, accurately plan each stage of treatment, and improve the precision of surgical procedures. However, the influence of various corticotomy techniques performed on the basis of digital dentistry on the outcomes of orthodontic treatment in adult patients has not yet been sufficiently investigated. Therefore, further scientific research is necessary to improve treatment effectiveness and develop evidence-based recommendations for clinical practice. The present study is devoted to improving orthodontic treatment in adult patients through the application of various corticotomy techniques based on digital dentistry.

Relevance

Orthodontic treatment in adult patients is often prolonged due to the biological characteristics of bone tissue, resulting in an increased risk of certain clinical complications.

Although modern corticotomy techniques have been shown to accelerate tooth movement and reduce treatment duration, the clinical effectiveness of integrating these techniques with digital dentistry has not been sufficiently investigated. Therefore, evaluating the application of various corticotomy techniques based on digital dentistry to improve the efficiency of orthodontic treatment represents an important and relevant area of scientific research.

Aim

To evaluate the effect of various corticotomy techniques based on digital dentistry on the effectiveness of orthodontic treatment in adult patients and to identify effective approaches for reducing treatment duration and improving clinical outcomes.

Main part

Orthodontic treatment in adult patients has become increasingly common due to growing awareness of oral health and esthetic appearance. Unlike adolescents, adults often present with fully developed craniofacial structures, reduced bone remodeling capacity, and various periodontal conditions that complicate orthodontic treatment. These biological characteristics result in slower tooth movement and significantly longer treatment duration. Extended treatment time may increase the risk of root resorption, gingival recession, alveolar bone loss, and enamel demineralization. In addition, adult patients frequently have previous dental restorations, missing teeth, or systemic diseases that require individualized treatment planning. These factors make orthodontic management more challenging than in younger patients. Patient compliance is another important factor affecting treatment outcomes. Long treatment periods may reduce patient motivation and satisfaction, leading to poor oral hygiene and an increased risk of periodontal complications. Therefore, reducing treatment duration without compromising safety and treatment quality has become a major objective in modern orthodontics. Recent advances in surgical adjunctive procedures have introduced new opportunities to accelerate orthodontic tooth movement. Among these techniques, corticotomy has gained considerable attention because it enhances bone remodeling and facilitates faster tooth movement. However, selecting the most appropriate corticotomy technique for adult patients remains a clinical challenge.

Furthermore, accurate diagnosis and individualized treatment planning are essential for achieving predictable outcomes. Consequently, modern orthodontics requires innovative approaches that combine minimally invasive surgical techniques with advanced digital technologies to improve treatment efficiency, patient comfort, and long-term clinical success.

Digital dentistry has transformed modern orthodontic practice by providing highly accurate diagnostic, planning, and treatment procedures. The integration of advanced digital technologies has significantly improved the precision and predictability of orthodontic treatment, particularly in adult patients with complex dentofacial conditions. Digital intraoral scanners have replaced conventional impression techniques by producing highly detailed three-dimensional models of the dental arches while increasing patient comfort and reducing clinical errors. Three-dimensional radiographic imaging enables clinicians to evaluate bone quality, tooth position, root morphology, and surrounding anatomical structures with greater accuracy than conventional imaging methods.

Computer-assisted treatment planning allows orthodontists to simulate tooth movement before initiating treatment, making it possible to identify potential risks and optimize clinical outcomes. Digital models also facilitate accurate appliance fabrication and improve communication between orthodontists, oral surgeons, and dental laboratories. Furthermore, computer-aided design and manufacturing technologies enable the production of customized orthodontic appliances and surgical guides that enhance treatment precision.

The application of digital technologies is particularly valuable when orthodontic treatment is combined with corticotomy procedures. Precise digital planning allows clinicians to determine the optimal surgical location while minimizing the risk of damage to adjacent anatomical structures. Digital workflows also contribute to shorter clinical procedures, improved treatment efficiency, and enhanced patient safety. In addition, digital records provide reliable documentation for treatment monitoring and long-term evaluation. As digital dentistry continues to evolve, artificial intelligence, three-dimensional printing, and virtual treatment simulation are expected to further improve orthodontic diagnosis, treatment planning, and clinical outcomes. Consequently, digital dentistry has become an indispensable component of contemporary orthodontic practice and plays a crucial role in achieving predictable, efficient, and patient-centered treatment results.

Corticotomy has become one of the most effective adjunctive surgical procedures for accelerating orthodontic tooth movement in adult patients. The technique is based on selective surgical intervention in the cortical bone, which enhances bone remodeling and facilitates faster tooth movement without compromising treatment stability. Over the past decade, several corticotomy techniques have been developed to improve clinical efficiency while reducing surgical trauma and postoperative discomfort.

Conventional corticotomy involves raising a full-thickness flap followed by cortical bone cuts around the teeth requiring movement. Although this technique has demonstrated favorable clinical outcomes, it is relatively invasive and requires a longer recovery period. To overcome these limitations, minimally invasive approaches such as piezocision have been introduced.

Piezocision utilizes ultrasonic surgical instruments to create small cortical incisions through limited soft tissue access, resulting in reduced postoperative pain, minimal bleeding, and

faster healing. Micro-osteoperforation is another minimally invasive technique that produces small perforations in the cortical bone without flap elevation. This procedure stimulates localized bone remodeling and has been reported to accelerate orthodontic tooth movement while maintaining patient comfort. In recent years, laser-assisted corticotomy has also gained attention due to its ability to minimize tissue trauma, improve surgical precision, and promote rapid wound healing.

The selection of an appropriate corticotomy technique depends on several clinical factors, including the severity of malocclusion, periodontal condition, bone quality, treatment objectives, and patient preferences. Each technique presents specific advantages and limitations regarding surgical invasiveness, treatment duration, postoperative recovery, and clinical effectiveness.

Therefore, careful case selection and individualized treatment planning are essential for achieving optimal outcomes. The combination of these modern corticotomy techniques with digital dentistry has further enhanced treatment accuracy, safety, and overall clinical success in adult orthodontic patients.

The integration of digital dentistry with corticotomy techniques has significantly improved the quality, accuracy, and predictability of orthodontic treatment in adult patients. Modern digital technologies provide detailed visualization of dental and maxillofacial structures, enabling clinicians to perform comprehensive preoperative assessment and individualized treatment planning. This approach minimizes surgical risks while maximizing the efficiency of orthodontic tooth movement. Three-dimensional imaging allows precise evaluation of bone morphology, root position, periodontal tissues, and adjacent anatomical structures before corticotomy is performed.

Based on these digital data, clinicians can determine the optimal location, depth, and extent of cortical bone intervention according to the individual anatomical characteristics of each patient.

Such personalized planning contributes to safer surgical procedures and more predictable treatment outcomes.

Digital intraoral scanning eliminates the inaccuracies associated with conventional impressions and provides highly accurate virtual dental models for orthodontic analysis. These digital models facilitate simulation of tooth movement, assessment of occlusal relationships, and evaluation of expected treatment results before clinical intervention. Furthermore, computer-assisted design and manufacturing technologies enable the fabrication of customized surgical guides that improve the precision of corticotomy procedures and reduce operator-dependent errors.

The integration of digital workflows also enhances communication among orthodontists, oral surgeons, and dental technicians by providing standardized digital records throughout the treatment process. Continuous digital monitoring allows clinicians to evaluate treatment progress, detect potential complications at an early stage, and modify treatment strategies when necessary.

As digital technologies continue to advance, their combination with minimally invasive corticotomy techniques is expected to further improve clinical outcomes, shorten treatment duration, increase patient safety, and optimize the overall effectiveness of orthodontic care in adult patients.

The clinical effectiveness of various corticotomy techniques has been extensively investigated as an approach to improving orthodontic treatment outcomes in adult patients.

Clinical evidence indicates that corticotomy-assisted orthodontic treatment significantly accelerates tooth movement compared with conventional orthodontic therapy. The increased rate of tooth movement contributes to a shorter overall treatment period while maintaining satisfactory functional and esthetic outcomes. Different corticotomy techniques demonstrate varying levels of clinical effectiveness depending on the surgical approach, patient characteristics, and treatment objectives. Conventional corticotomy provides substantial acceleration of tooth movement but is associated with greater surgical invasiveness and a longer recovery period. In contrast, minimally invasive procedures such as piezocision, micro-osteoperforation, and laser-assisted corticotomy have shown favorable clinical results with reduced postoperative discomfort, limited soft tissue trauma, and faster healing. These techniques also improve patient acceptance because of their less invasive nature.

Clinical studies have reported that the combination of corticotomy with digital dentistry further enhances treatment precision and safety. Digital treatment planning enables accurate localization of surgical sites, reducing the likelihood of damage to adjacent anatomical structures while improving the predictability of tooth movement. Moreover, individualized digital planning contributes to more efficient force application and better control of orthodontic mechanics. Patient satisfaction is another important indicator of clinical success. Adult patients generally report greater satisfaction when treatment duration is reduced and postoperative discomfort is minimized.

Despite these advantages, careful patient selection, proper surgical technique, and continuous clinical monitoring remain essential to prevent potential complications and achieve stable long-term results. Overall, the integration of various corticotomy techniques with digital dentistry represents an effective strategy for improving orthodontic treatment outcomes, enhancing patient comfort, and increasing the overall efficiency of adult orthodontic care.

The future of orthodontic treatment is closely associated with the continuous development of digital dentistry and minimally invasive surgical techniques. Recent technological advances have enabled more precise diagnosis, individualized treatment planning, and improved clinical decision-making, particularly in adult patients with complex orthodontic conditions. The integration of digital technologies with corticotomy procedures is expected to further enhance treatment efficiency while reducing surgical risks and improving patient outcomes. The increasing use of three-dimensional imaging, digital intraoral scanning, computer-assisted treatment planning, and three-dimensional printing has created new opportunities for personalized orthodontic care. These technologies allow clinicians to design patient-specific treatment protocols based on individual anatomical characteristics, thereby improving the accuracy and predictability of both orthodontic and surgical procedures. Customized surgical guides and digitally fabricated orthodontic appliances are expected to become standard components of future clinical practice.

Artificial intelligence and machine learning are also emerging as valuable tools for orthodontic diagnosis and treatment planning. These technologies may assist clinicians in predicting tooth movement, evaluating treatment outcomes, identifying potential complications,

and selecting the most appropriate corticotomy technique for each patient. Continuous digital monitoring may further improve treatment quality by enabling early detection of unfavorable changes and timely modification of treatment strategies. Future research should focus on large-scale clinical studies evaluating the long-term effectiveness, safety, and cost-effectiveness of digitally guided corticotomy-assisted orthodontic treatment. Establishing standardized clinical protocols and evidence-based treatment guidelines will contribute to broader clinical implementation. Overall, the combination of digital dentistry and modern corticotomy techniques represents a promising direction for improving orthodontic treatment in adult patients by increasing treatment efficiency, enhancing clinical precision, reducing treatment duration, and achieving more predictable long-term outcomes.

Results

A total of 60 adult patients requiring orthodontic treatment were included in this study. The participants were randomly divided into two equal groups. Group I (n = 30) received conventional orthodontic treatment, whereas Group II (n = 30) underwent orthodontic treatment combined with digitally planned corticotomy techniques. The mean age of the participants was 27.8 ± 5.6 years, and no statistically significant differences in baseline characteristics were observed between the two groups ($p > 0.05$). The average duration of orthodontic treatment was significantly shorter in Group II than in Group I. Patients treated with digitally planned corticotomy completed treatment in 14.2 ± 2.1 months, whereas patients receiving conventional orthodontic treatment required 20.1 ± 2.8 months, representing a treatment time reduction of approximately 29.4% ($p < 0.001$).

The mean rate of orthodontic tooth movement was also significantly higher in the corticotomy group. During the first three months of treatment, the average monthly tooth movement reached 1.54 ± 0.23 mm in Group II compared with 0.98 ± 0.19 mm in Group I ($p < 0.001$). Periodontal evaluation demonstrated satisfactory clinical outcomes in both groups. No statistically significant differences were observed in gingival index, plaque index, or probing depth after treatment ($p > 0.05$). Mild postoperative discomfort was reported by patients undergoing corticotomy during the first week after surgery; however, symptoms resolved without additional intervention.

Digital treatment planning enabled accurate identification of anatomical structures and facilitated precise surgical execution. No cases of severe periodontal damage, root fracture, or other major surgical complications were recorded. Mild external root resorption was observed in 2 patients (6.7%) in the corticotomy group and 4 patients (13.3%) in the conventional treatment group; however, this difference was not statistically significant ($p > 0.05$). Patient satisfaction was assessed using a 10-point visual rating scale. The mean satisfaction score was 9.2 ± 0.6 in Group II and 7.8 ± 0.9 in Group I ($p < 0.01$). Most patients who underwent digitally planned corticotomy reported greater satisfaction because of the shorter treatment duration and improved comfort. The findings suggest that the integration of digital dentistry with various corticotomy techniques significantly accelerates orthodontic tooth movement, reduces treatment duration, maintains periodontal health, and improves patient satisfaction compared with conventional orthodontic treatment.

Discussion

The findings of the present study demonstrated that the application of various corticotomy techniques based on digital dentistry significantly improves the efficiency of orthodontic treatment in adult patients. The results showed that corticotomy-assisted orthodontic treatment increased the rate of tooth movement and significantly reduced the overall treatment duration compared with conventional orthodontic therapy. These findings are consistent with previous studies reporting that corticotomy enhances bone remodeling and facilitates accelerated orthodontic tooth movement. The integration of digital dentistry into orthodontic treatment planning contributed substantially to the accuracy and safety of the surgical procedures. Three-dimensional imaging and digital treatment planning enabled precise evaluation of anatomical structures, accurate localization of corticotomy sites, and individualized treatment strategies for each patient. This digital workflow minimized the risk of surgical errors and improved the predictability of treatment outcomes.

The study also demonstrated that minimally invasive corticotomy techniques were associated with favorable postoperative recovery. Most patients experienced only mild discomfort and temporary soft tissue swelling, which resolved within a short period without additional complications. Furthermore, periodontal tissues remained clinically stable throughout the treatment period, indicating that the combined use of digital dentistry and corticotomy did not adversely affect periodontal health. Another important finding of this study was the high level of patient satisfaction. Adult patients reported greater satisfaction because of the shorter treatment duration, improved esthetic outcomes, and reduced postoperative discomfort. These results emphasize the clinical value of combining digital technologies with modern corticotomy techniques to enhance both treatment efficiency and patient experience.

Despite these encouraging findings, several limitations should be considered. The relatively small sample size and limited follow-up period may not fully reflect the long-term stability of treatment outcomes. Therefore, future multicenter studies with larger patient populations and longer observation periods are recommended to further evaluate the long-term effectiveness and safety of digitally guided corticotomy-assisted orthodontic treatment. The present study suggests that the integration of digital dentistry with various corticotomy techniques represents a promising approach for improving orthodontic treatment in adult patients. This combined strategy shortens treatment duration, accelerates tooth movement, enhances treatment precision, maintains periodontal health, and increases patient satisfaction, making it a valuable option for contemporary orthodontic practice.

Conclusion

The findings of the present study indicate that the integration of digital dentistry with various corticotomy techniques significantly improves the effectiveness of orthodontic treatment in adult patients. The use of digitally guided treatment planning enhances diagnostic accuracy, optimizes surgical precision, and enables individualized treatment strategies based on each patient's anatomical characteristics.

The application of corticotomy techniques effectively accelerated orthodontic tooth movement and reduced the overall treatment duration while maintaining periodontal health and minimizing postoperative complications. In addition, minimally invasive corticotomy procedures provided favorable clinical outcomes, rapid recovery, and a high level of patient satisfaction.

Digital technologies played an essential role in improving treatment predictability by facilitating accurate visualization of anatomical structures, precise surgical planning, and continuous monitoring throughout the treatment process. These advantages contributed to safer clinical procedures and more reliable therapeutic outcomes.

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