https://doi.org/10.33472/AFJBS.6.6.2024. 6806-6811

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Mri Application In Dental Implant Surgery

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Article Info

Volume 6, Issue 6, July 2024

Received Date: 25-Apr-24

Revised date: 3-June-24

Accepted Date: 20-June-24

doi: 10.33472/AFJBS.6.6.2024.6806-6811

ABSTRACT:

Aim: -The purpose of this study is to assess the precision of dental MRI in implant surgical planning.

Materials and method- In this prospective investigation, patients in need of dental implants underwent implant planning and surgical guide production using a 0.4-mm isotropic, artifact-suppressed, 3T MRI protocol. During a later reference cone beam computed tomography (CBCT) scan, surgical guides were inserted intraorally. Dental MRI and CBCT datasets were co-registered for each participant in order to calculate the angular and three-dimensional discrepancies between surgically guided and intended implant locations.

Results:-Out of 45 study participants, 50 implants were designed and assessed. The entry point's mean three-dimensional deviation was 1.2 ± 0.5 mm, whereas the apex's was 1.4 ± 0.6 mm. The variance in angular mean was 2.4 ± 1.5°. For 30.00% of implant sites and 2% of all implant sites, CBCT-based MRI plan modifications were required for implant position and axis. Compared to the group with tooth gaps, the group with reduced dental arches had greater changes.

Conclusion: According to this feasibility study, dental MRI is a dependable and precise enough method for producing surgical guides. However, before it is applied to implant planning outside of clinical trials, more research is required to improve its accuracy.

KEYWORD: MRI, CBCT, Implant

1. Introduction

In contemporary dentistry, dental implant implantation has become a well-liked and dependable treatment method in recent years because to three-dimensional cross-sectional imaging and navigation. Dental implants are the best long-term option with good survival rates for replacing one or more teeth, when considering medical, financial, psychological, and social factors[1]. However, a number of local and systemic factors—including those linked to the patient, the implant, the surgical method, and the environment—are important and crucial to the long-term success of dental implant surgery[2].

Nowadays, dental diagnosis and treatment planning at the first and second levels heavily rely on radiographic imaging[3]. Currently, magnetic resonance imaging (MRI), cone beam computed tomography (CBCT), and computed tomography (CT) equipment are used to get three-dimensional images of the craniofacial region. Cone beam computed tomography (CBCT) has made three-dimensional imaging prescription more prevalent in the fields of endodontics, periodontology, implantology, and orthodontics. In these particular fields, specialized software is becoming more and more helpful[4]. When it comes to treatment planning, CBCT has many advantages over traditional two-dimensional radiographic imaging. But the biggest drawback is the high radiation exposure of patients, which prevents doctors from using this kind of examination frequently in a limited amount of time. As a result, each case requires a careful evaluation of the expected risk/benefit ratio[5].

Currently, guided implant surgery, or prosthetically driven backward planning, is crucial to implant surgery[6]. Using a surgical guide, the optimal design of the prosthetic restoration (such as an implant-supported single crown) determines the implant's three-dimensional (3D) position, which is then transferred into the patient. 3D imaging is necessary to determine the ideal prosthetically related implant site within the constraints of the accessible alveolar bone[7,8].

Since MRI has the great advantage of not using ionizing radiation—a biological damage associated with other three-dimensional imaging techniques like CT and CBCT—it has become essential for the non-invasive diagnosis of soft tissue diseases. MRI is a well-established imaging technique in various areas of medicine. In terms of spatial resolution and data visualizing capability in the views of the transverse and panoramic planes, which are most recognizable to dentists, MRI is nearly equivalent to the latter[9].

Therefore, we wanted to see if implant planning decisions based on dental MRI would be different from those based on CBCT, the reference imaging technique, and if surgical guidance produced from dental MRI would be accurate enough to insert implants. Therefore, the goals of this study was to assess the accuracy and reliability of decisions made about implant planning based on dental MRI.

2. Methods

50 patients participated in this prospective trial, which was approved by the institutional ethical committee.For every subject, written informed permission was acquired. The study included patients in need of dental implants, those with teeth in both quadrants of the jaw to allow for reliable guide positioning, those with stable medical conditions to undergo implant surgery, and those who met the following exclusion criteria: two stages of surgery with separate bone augmentation and implant insertion, age below 18 years old, pregnancy, and claustrophobia.

Each participant had a 0.4-mm isotropic, artifact-suppressed, proton-weighted dental MRI scan of the relevant jaw in addition to full-arch impressions for a stone cast. The dental MRI examination employed a splint technique to enable precise segmentation of tooth surfaces in

MRI data. An established software tool for guided implant surgery was then used to import and co-register data from both the digitalized stone cast and the dental MRI.

In compliance with the implant manufacturer's specifications and established clinical criteria, the dentist was asked to construct a treatment plan that included the implant type and dimensions, the type and requirement of bone augmentation, and the position and axis of the implant.

If bone augmentation was necessary, it was necessary to specify the kind of augmentation. Each participant received a tooth-supported guide with a thickness of 3 mm once the ideal implant position and axis were determined. Lastly, for guided implant planning, a CBCT scan was performed on each subject.

Surgical guides with a metal marker were inserted intraorally during the CBCT scans in order to convert the MRI-based implant placements and axes into the CBCT datasets. In order to guarantee that all opposing teeth on the surgical guide were securely supported, wooden spatulas were also inserted intraorally. Using the tooth surfaces as references, the CBCT data were co-registered with the dental MRI and input into the same implant planning software for the accuracy analysis. The surgically guided implant position was determined by utilizing the marker included in the surgical guide during the CBCT exams. Next, a comparison was made between the surgically guided implant position in the CBCT pictures and the planned implant position in the dental MRI datasets. Lastly, the deviation of the implant axis as well as the 3D deviation of the entry point and implant apex were computed.

SPSS was used to analyze the data (version 22, SPSS Inc.). The Mann-Whitney U or two-tailed Student t test was performed to compare the accuracy of implant sites utilized to reconstruct shorter dental arches vs those in tooth gaps. A significant threshold of $p < 0.05$ was established.

3. Results

In total, 50 participants were consecutively enrolled in this study. 5 participants could not be included in the final analysis. Thus, 50 implant sites among 45 participants were planned and evaluated in total in which 22 participants were female while 23 were male. Mean age in the study participant was found to be 52.6 ± 10.57 years. Bone augmentation procedures were performed for more than half of implant sites (30).

For 45 of the 50 implant sites, the decision whether to perform bone augmentation or not was made correctly on the basis of dental MRI planning (κ 0.84; 95% CI 0.74–1). For five sites, the need for bone augmentation was not predicted by dental MRI, but was subsequently identified based on CBCT images. Dental MRI-based planning did not incorrectly predict the need for bone augmentation for any site which was compared with re-evaluation after CBCT.

For all implant sites where the need for bone augmentation was identified on the basis of dental MRI, the decision was confirmed by CBCT. For 34 out of 50 sites (68.00%), the planned implant position was not altered after the CBCT-based re-evaluation. Small changes were made to the implant position of 15 sites (30.00%; mean change of 1.5 mm) and to the implant axis of one sites (2.00%; mean change of 10°).

Evaluation of the accuracy of the dental MRI based surgical guides for the 50 planned implants revealed mean 3D deviations of 1.2 ± 0.5 mm at the entry point (minimum 0.4 mm; maximum 2.5 mm) and 1.4 ± 0.6 mm at the implant apex (minimum 0.3 mm; maximum 3.2 mm). In addition, a mean angular deviation of $2.4 \pm 1.5°$ (minimum 0.5°; maximum 6.0°) was observed. Slightly larger deviations were found for implant sites with shortened dental arches vs. implant sites in tooth gaps for the 3D deviation of entry point/implant apex, as well as the angulation, without reaching statistical significance.

Table 1:- Comparison of requirement of bone augmentation procedures

Bone Augmentation	MRI	CBCT	p-value
Sinus Lift	6	8	0.163
Bone Chips	5	7	
Bone split	2	3	
Not required	37	32	

Mann Whitney U test

Table 2:- Comparison of correction after CBCT in Free ending and Tooth Gap

	Free Ending	Tooth Gap	p-value
Position of entry point	1.1 ± 1.5	0.3 ± 0.2	**0.028***
Angulation	1.5 ± 3.2	0.5 ± 0.2	**0.016***

Mann Whitney U test, *- Statistically significant

Table 3:- Comparison of Accurary of MRI- derived surgical guide in Free ending and Tooth Gap

	Free Ending	Tooth Gap	p-value
3D deviation at entry point	1.3 ± 0.5	1.2± 0.6	0.828
3D deviation at apex	1.5 ± 0.4	1.4 ± 0.7	0.716
Angular deviation [°]	2.4 ± 1.2	2.2 ± 1.5	0.642

t-test

4. Disscussion

This study demonstrates the excellent reliability of dental MRI-based backward planning and the resulting rather accurate surgical guidance. However, it also shown that the approach is currently unable to meet the most stringent surgical and prosthetic planning requirements in every situation.

In comparison to implant sites between neighboring teeth, the subgroup analysis showed more and significantly bigger adjustments of MRI-derived implant position/angulation in free-ending positions, as well as slightly less accurate MRI-derived surgical guidance (not statistically significant). Patients with shortened arches may have less accurate MRI and digital impression coregistration because of the restricted spatial distribution of available tooth surfaces. This could result in a less accurate transfer of the virtual implant position into the surgical guide. This outcome is consistent with earlier research that found a comparable relationship between accuracy and the quantity of remaining teeth.[10,11]

An apical deviation of 0.49 mm (minimum 0.13, maximum 1.09 mm) was recorded by Kühl et al. In contrast, our study's apical deviation was higher (mean 1.3 ± 0.7; lowest 0.2; maximum 3.1 mm). This might be because of our in vivo environment, which includes motion artifacts, as well as a poorer scanning resolution (0.4 mm isotropic; Kühl et al.'s optical scanner had an accuracy of about 15 µm). [12]

When it comes to guided implant surgery, MRI is clearly superior than CBCT because it provides an adequate representation of the tooth and bone structure without exposing patients to ionizing radiation. Additionally, because of the superior contrast of soft tissues in MRI, it may be possible to image peripheral nerve tissue directly. Direct nerve visualization like this could be useful for presurgical planning before implant dentistry, as well as before other treatments like orthognathic surgery or wisdom teeth extraction.[13] MRI may make it possible to evaluate implants after surgery and may present a three-dimensional means of identifying periimplant bone abnormalities.[14]

To determine the true potential of computer guided implant surgery, the benefits provided by MRI must be weighed against the associated drawbacks. Initially, challenges could stem from motion and susceptibility artifacts, which have been covered in the previous article. Secondly, certain conditions like having a pacemaker, cochlear implants, or neurostimulators make something contraindicated[15]. Third, there are financial and supply constraints with the MRI-based method. For example, there are still certain precise sequences that are not publicly available for the best depiction of dental features. Compared to CBCT devices, the purchase and maintenance expenses of MRI devices are significantly greater[16]. Consequently, compared to CBCT, there is a much lower chance of on-site utilization in dentistry practices, and dentists would need to collaborate with radiology departments that provide dental MRI applications. There are a few issues with this specific dental MRI application that need to be resolved. Our reliability assessment's usefulness is rather constrained. Furthermore, dental MRI's present clinical application is limited by its expense[17].

5. Conclusion

To conclude, the study adds to the body of knowledge by demonstrating the validity of dental MRI-based backward planning and the production of surgical guides that are accurate enough to insert implants. However, more investigation is required to improve dental MRI accuracy, for instance, by lowering acquisition time to minimize motion artifacts or raising spatial resolution. These results may contribute to radiation-free backward implant planning led by prosthetics. This is especially critical for younger people, as they are more radiation sensitive. Before this imaging modality is employed outside of clinical studies, more research on dental MRI and implant placement is necessary.

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