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Novel Silk Fibroin Nanofiber Membrane Using Minimally Invasive Surgery in Treatment of Periodontal Intrabony Defects: A Randomized Clinical Trial

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Abstract:

Objectives: The aim of this study was to compare the radiographic objectives of a novel silk fibroin (SF) nanofiber membrane to collagen membrane (CM) as a regenerative material for treating of intrabony periodontal defects using minimally invasive surgery in a prospective, randomized, single-blind, controlled study design.

Patients and Methods: Thirty periodontal intrabony defects in thirty patients were included in the study. Patients were randomly assigned into three groups; Group 1: Minimally Invasive Surgical Technique (MIST), Group 2: MIST with CM, Group 3: MIST with Silk Fibroin (SF) nanofiber membrane. Radiographic parameters including linear, defect angulation measurements and the intrabony component fill were evaluated at baseline and six months following surgical therapy.

Results: The study found a significant gain in radiographic parameters between baseline and after a 6-month follow-up period. In this study, radiographically regarding intra-bony component fill there was insignificant difference as P = 0.18, 0.44, and 0.07 regarding G1, G2, and G3 respectively.

Conclusions: The study's overall findings indicate that, when treating intrabony periodontal defects, minimally invasive surgery with SF membrane is just as effective as minimally invasive surgery with CM. Both groups seem to achieve results that are comparable to those of minimally invasive surgical technique alone.

Keywords: Intrabony Defects, Regenerative Membranes, Minimally Invasive Techniques, Cone Beam Computed Tomography

1. Introduction

A long-term, persistent periodontal inflammation caused by bacteria that extends through the gingiva is known as periodontitis. The progressive and irreversible loss of connective tissue connection is its defining feature.[1] Debridement of the tooth surface and surrounding tissues using for conservative, non-surgical therapy includes scaling and root planning. The underlying bone for complete debridement, pocket depth reduction, periodontal regeneration, and preservation of the periodontium in a healthy state are achieved with periodontal flap surgery, all of which are possible with regular at-home dental care.[2]

The purpose of the regeneration of periodontal tissue is to enhance the clinical outcomes of teeth that have been considered damaged, namely those that have deep pockets and a loss of supporting tissues.[3] Deep pockets that remain following periodontal therapy have been related to infrabony defects, which increases the possibility of further periodontal degradation leading to tooth loss.[4] Regenerative therapy has been advocated for the treatment of intrabony defects and has been shown to enhance clinical results in terms of bone fill. Several materials have been used for regenerative treatment of intrabony defects, including barrier membranes, bone grafts, and biological factors, as well as their combinations However, complete and functional periodontal regeneration is still a challenge.[5]

One of the most essential facets of treating intrabony defects is guided tissue regeneration (GTR) therapy. Presently available membranes, both resorbable and non-resorbable, function as a physical barrier to prevent the downgrowth of connective and epithelial tissue into the defect, promoting the regeneration of periodontal tissues. The "perfect" membrane for periodontal regeneration therapy has not yet been created, and these typical membranes have numerous structural, mechanical, and biofunctional drawbacks. Based on a graded-biomaterials approach, it was hypothesized that as the next generation of GTR membranes for periodontal tissue engineering, a physiologically active, spatially modified, and functionally graded nanofibrous material that closely resembles the native extracellular matrix (ECM) may be successful.[6] Conventional membranes don’t express any antimicrobial properties.[7] In addition, one of the current limitations of the conventional regenerative therapies is the lack of the mechanical properties with a low capability of extrinsic factors production for efficient osteogenesis.[8] These limitations may affect regeneration efficacy.

Recently, different membranes extracted from natural products are nowadays depended on. Among these is the silk fibroin nanofiber membrane which is natural protein extracted from the cocoons of the silkworm.[9] It can be fabricated within nanoscale. Silk fibroin (SF) nanofiber can be used in GTR because of its favorable properties, including biodegradability, bioavailability, good cell adhesion, intrinsic antimicrobial property and proper mechanical properties.[10] Silk fibroin nanofiber membrane showed excellent osteogenic cell differentiation, proliferation, renewed bone growth.[14] When compared to a conventional membrane, the silk mat's center portion demonstrated greater strength and the capacity to form new bone. In addition, it displayed a lower level of immunological response in comparison to the outer and inner layers. Moreover, it demonstrated significant promise as a more biocompatible guided tissue regeneration (GTR) membrane. It was possible to develop biodegradable membrane scaffolding based on silk that is not affected by foreign body reactions.[11]

Critical factors to achieve successful periodontal regeneration are related to the ability of the surgical procedure to create and maintain adequate space for the blood clot and provide its stability and protection through primary closure.[12] Over the last twenty years, research has concentrated on creating less invasive flap designs and clinical procedures using papilla preservation flaps and

microsurgical instruments to reduce patient morbidity, improve clot stabilization, minimize periodontal tissue trauma, and enhance wound/soft tissue stability.[13] Compared to traditional surgical methods, the use of such minimally invasive treatments has produced results that are on par with or even better.[14]
The combination of silk fibroin nanofiber membranes, the minimally invasive technique, and the comparison with conventional materials are assumed to be a point of most investigation. Finally, this study was conducted.

2. Patients and Methods

Sample size calculation:

The primary objective variable in this study was the change in intrabony component fill as measured by cone beam CT six months after surgery, Therefore, sample size from each group needed to detect a radiographic bone fill difference of 1.5±1.2 mm between treatments with a significance level of 5% and a power of 80%. An estimated 20% dropout will be allowed in the final sample size calculation (n=10).[15]

Study design, subject population, and compliance with ethical standards

A prospective, controlled, single-blind, randomized clinical trial was used to design this investigation. Using minimally invasive surgery, the study assessed radiographically the regenerative potentials of silk fibroin (SF) nanofiber membrane for the regenerative treatment of intrabony periodontal defects. Thirty-six patients with 30 intrabony periodontal defects were chosen from the outpatient clinic of the Faculty of Dentistry, Oral Medicine and Periodontology Department, October 6 University. The October 6 University Faculty of Dentistry's Research Ethics Committee granted approval for the study (***IEC: RECO6U/22-2022***). An informed permission form was signed by each patient involved in this investigation, and the trial was carried out.

Inclusion and Exclusion Criteria:

The patient was older than eighteen. Individuals with Stage III, Grade C periodontitis.[16] essential teeth with single or multiple roots in the mandible or maxilla. Four weeks after the start of treatment, the intraosseous defect location should have a probing depth (PD) of at least five millimeters. Intrabony defects (IBDs) extend equal to or less than 3 mm from the alveolar crest to the defect base, involving two or three walls. Radiographic examination (Periapical X-ray) was used to estimate this. At the areas involved, there is no history of periodontal surgery. History of following periodontal recall and dental hygiene guidelines. Following phase I therapy, the full mouth plaque index and the bleeding on probing index were equal to or less than 20%.
The subsequent patients were not included in the research: women who are expecting or nursing. Individuals with any systemic illnesses, such as immunological deficits, diabetes, etc., that could influence how well periodontal therapy works. usage of tobacco in any form at the moment.
The participants were equally divided into three treatment modalities in deep intrabony defects (10 each): ***Group 1:*** Minimally Invasive Surgical Technique (MIST). ***Group 2:*** MIST combined with CM. ***Group 3:*** MIST combined with SF nanofiber membrane.
The objective was to measure intrabony defect component fill.

Preoperative preparation;

Phase I therapy, which included scaling, root planing, advice for proper oral hygiene, and dental prophylaxis if necessary, made up the first course of treatment. Before deciding to have surgery, a month-long assessment of good dental hygiene and gingival inflammation control (PI <15%) was completed. To determine if the patients were suitable for the necessary surgery, all radiographic criteria were reexamined. Radiographic evaluations were performed.

Radiographic Assessments;

Cone beam computed tomography (CBCT)* was recorded at baseline, 3, and 6 months after surgery for analysis by an outside radiology specialist. The results included the intrabony component (IBC) filled bone. (IBC) was computed by subtracting the CEJ to Alveolar Crest distance from the CEJ to BD distance (Figure 1)[17]. The angle between the lateral bony wall and the root surface was used to calculate defect angulation (Figure 2)[18].

Figure (1). CBCT sagittal cut showing Linear measurements of an intrabony defect at mesial aspect of upper right first premolar before therapy: first line A) length from CEJ: cemento-enamel junction; BD: most apical extension of the bony defect. The second line B) AC: alveolar crest; BD: most apical extension of the bony defect.

* Planmeca ProMax® 3D Mid Machine with Planmeca Romexis Viewer 4.4 software

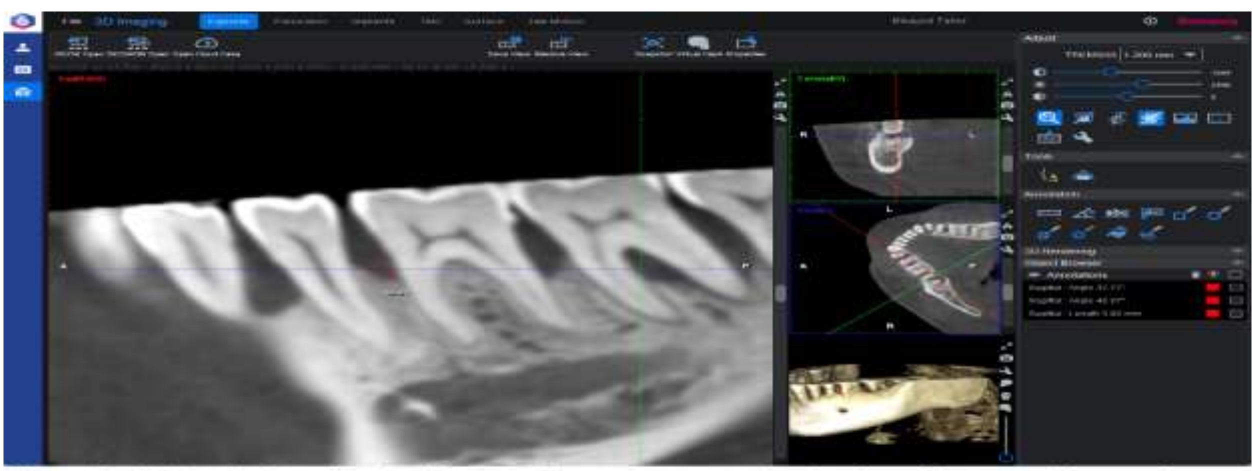


Figure (2). CBCT sagittal cut showing defect angulation measurements of an intrabony defect at mesial aspect of upper right first premolar before therapy: defect width, angle between root surface and lateral bony wall.

Materials

Silk Fibroin (SF) nanofiber membrane is a courtesy of Prof.Dr.Ahmed Youssef Gamal. Cocoons were degummed, soaked, dried, and dissolved in LiBr solution. Silk fibers were dissolved, filtered, and dialyzed for 3 days to create SF sponge, which was then lyophilized. SF solution was prepared by dissolving SF in formic acid, mixed with Polylactic Acid, and electrospun nanofibers using an electrospinning system at 20 kV and 0.2 ml/h flow rate.[19]

Surgical procedures

Following phase 1 therapy, local anesthetic nerve blocks or local infiltrations with 4% Articaine containing 1:100.000 epinephrine were used for all surgical procedures. The study involved three surgical procedures for a tooth defect. In group 1, a 15C blade was used for buccal and lingual sulcular incisions[20], with a tooth stretched mesially and distally from the intrabony defect to reach the defect-associated inter-dental papilla. A tiny full thickness trapezoidal flap was lifted to reveal 2 mm of healthy bone apical to the defect base. The defects were debrided, and any residual plaque and calculus were removed. The surgical site was rinsed with sterile saline solution and a 5-0 non-resorbable suture was used to secure the flap. In group 2, a collagen group was treated using the same surgical technique, with a CM membrane placed in the defect site and trimmed to fit the recipient site. The silk fibroin nanofiber membrane was used in group 3 which was used in the fresh condition, was placed in the defect site. The membrane was trimmed to fit the recipient site and at least 2 mm below the adjacent bone on each side of the root. All the surgical procedures were performed by the same periodontist.

Post-surgical instruction and infection control

Postoperative instructions were given in writing and orally to every patient. For one week, 500 mg of amoxicillin was provided every eight hours.[21] For two days, take 600 mg of ibuprofen twice a day. Patients were instructed to rinse their mouths twice a day with a mouthwash containing 0.12% chlorhexidine digluconate. They were told not to clean their teeth or their interdental spaces around the surgery sites. Additionally, for one month, clean the surgical sites using a cotton pellet soaked in a 0.12% chlorhexidine solution.

Post-surgical supportive periodontal care

Two weeks following the procedure, the sutures were taken out. Dental prophylaxis was advised six weeks after surgery, and the patient was told to start using a mechanical toothbrush again. For professional prophylaxis, plaque control, and healing evaluation, all patients were called back once a week in the first month, twice a month in the third, and once a month until the final examination six months after surgery. Unaware of the surgical approach employed for each group, a periodontist conducted pre- and post-surgical clinical assessments. Furthermore, in order to prevent bias, the statistician received the data without knowing the precise surgical method used on each treatment group.

Statistical analysis:

For statistical analysis, all of the data were gathered and tallied. Microsoft Excel 2016, Graph Pad Prism, and SPSS 20® were used for statistical analysis. Every radiography measurement showed a data distribution that was normal. As a result, the Repeated Measures ANOVA test and Tukey's Post Hoc test were used for the intragroup comparison, which compared intervals within each group, and the One-Way ANOVA test and Tukey's Post Hoc test were used for the intergroup comparison, which compared groups.

Table -1: Radiographic outcomes:

	G 1	G 2	G 3	P value

I. Radiographic Parameters:		M	SD	M	SD	M	SD	
CEJ-BD	**baseline**	8.2 [a]	1.64	7.23 [ab]	2.53	5.968 [b]	0.21	0.02*
	after 3	7.931 [a]	1.58	5.706 [b]	1.48	4.904 [b]	1.11	0.0001*
	after 6	7.669 [a]	1.53	5.514 [b]	1.36	4.83[b]	1.09	0.0001*
CEJ-AC	**baseline**	4.39 1 [a]	0.88	3.385 [b]	0.26	2.884 [b]	0.79	0.0001*
	after 3	3.962 [a]	0.79	2.519 [b]	0.21	2.63 [b]	1.03	0.0001*
	after 6	3.69 [a]	0.74	2.379 [b]	0.18	2.565 [b]	1.04	0.001*
Angle	**baseline**	30.68 a	6.14	44.60 b	3.29	37.47 c	0.42	0.0001*
	after 3	23.97 a	4.8	39.43 b	3.14	34.19 c	1.8	0.0001*
	after 6	23.27 a	4.65	38.11 b	3.17	33.10 c	1.58	0.0001*
The intra-bony component fill	**baseline**	3.809 [a]	0.76	3.792 [a]	1.13	3.085 [a]	1	0.18
	after 3	3.97 [a]	0.79	3.165 [ab]	1.29	2.274 [b]	0.08	0.001*
	after 6	3.979 [a]	0.8	3.136 [b]	1.18	2.266 [b]	0.05	0.0001*

**Significant difference as P<0.05.*
Means with different superscript letters were significantly different as P<0.05.
Means with the same superscript letters were insignificantly different as P>0.05.

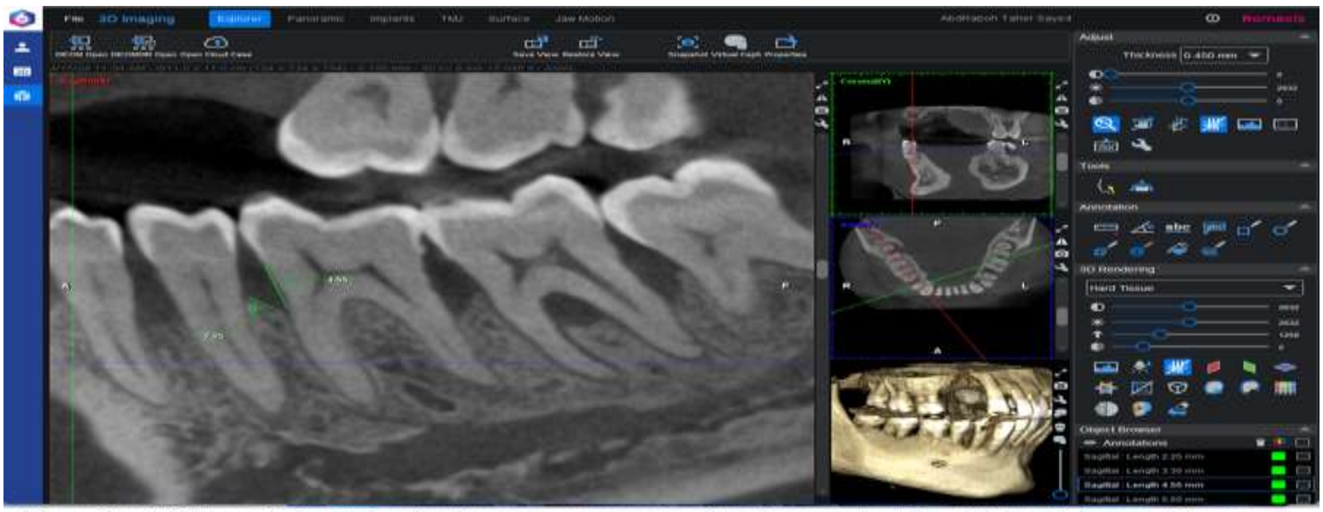
Radiographic objectives:

Changes in radiographic parameters are reported in Table 1. At linear measurement (CEJ–BD)(Figure 3, Table 1) there was a significant difference in group3 (P=0.0001), there was a significant decrease from (5.96 ± 0.21) at baseline to (4.904 ± 1.11) after 3 months, while there was insignificant decrease after 6 months to (4.83 ± 1.09). At baseline: Group1 (8.2 ± 1.64) was significantly the lowest, group3 (5.96 ± 0.21) was significantly the highest, while Group2 (7.23 ± 2.53) revealed insignificant difference with other groups. After 3 months: Group1 (7.931 ± 1.58) was significantly the lowest, while there was insignificant difference between group2 (5.706 ± 1.48) and group3 (4.904 ± 1.11). After 6 months group 1 (7.66 ± 1.53) was insignificantly the lowest, while there was insignificant difference between group2 (5.51 ± 1.36) and group3 (4.83 ± 1.09).

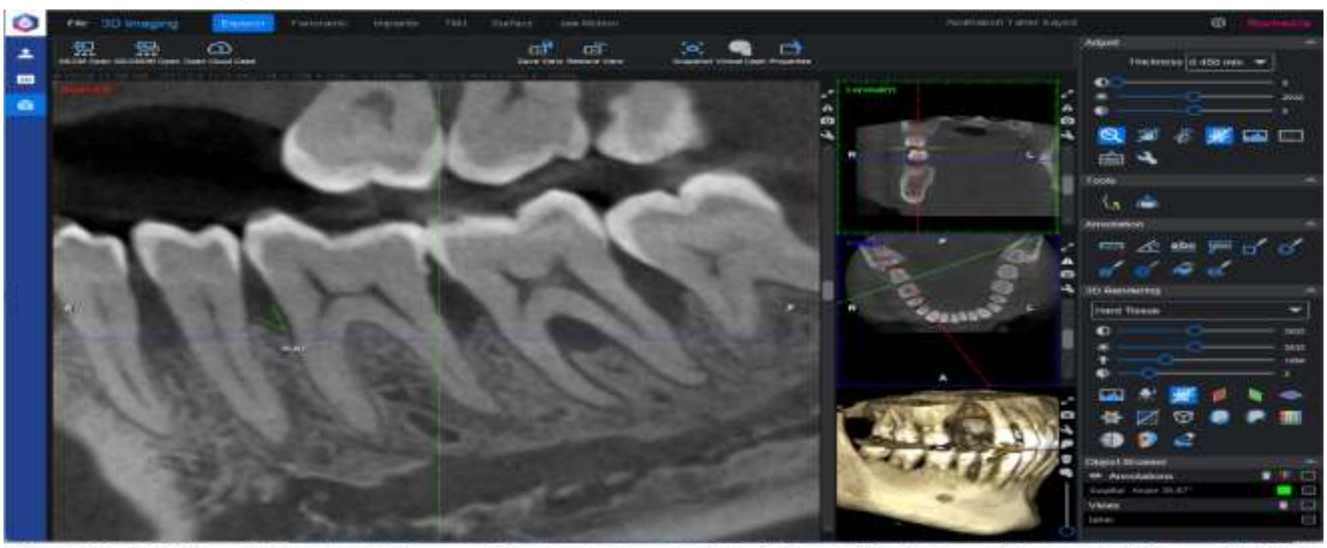
At linear measurement (CEJ– AC)(Figure 3, Table 1) there was a significant difference in group2 (P=0.0001), there was a significant decrease from (3.38± 0.26) at baseline to (2.51 ± 0.21) after 3 months, while there was insignificant decrease after 6 months to (2.37 ± 0.18). At baseline: Group1 (4.39 ± 0.88) was significantly the lowest, while there was insignificant difference between group2 (3.38 ± 0.26) and group3 (2.88 ± 0.79). After 3 months: Group1 (3.96 ± 0.79) was significantly the lowest, while there was insignificant difference between group2 (2.51 ± 0.21) and group3 (2.63 ± 1.03). After 6 months insignificant (3.69 ± 0.74) was significantly the lowest, while there was insignificant difference between group2 (2.37 ± 0.18) and group3 (2.56 ± 1.04).

At the defect angulation (Figure 4, Table 1) the G1: there was a significant decrease from (30.68± 6.14) at baseline to (23.97 ± 4.8) after 3 months, while there was insignificant decrease after 6 months to (23.26 ± 4.65) as P=0.01. G2: there was a significant decrease from (44.6± 3.29) at baseline to (39.43 ± 3.14) after 3 months, while there was insignificant decrease after 6 months to (38.11 ± 3.17) as P=0.0001. G3: there was a significant decrease from (44.6± 3.29) at baseline to (39.43 ± 3.14) after 3 months, while there was insignificant decrease after 6 months to (38.11 ± 3.17) as P=0.0001. At baseline: Group1 (30.86 ± 6.14) was significantly the lowest, then group3 (37.47 ± 0.42), while group2 (44.6 ± 3.29) was significantly the highest. After 3 months: Group1 (23.97 ± 4.8) was significantly the lowest, then group3 (34.19 ± 1.8), while group2 (39.43 ± 3.14) significantly the highest. After 6 months: Group1 (3.69 ± 0.74) was significantly the lowest, then group3 (2.56 ± 1.04), while group2 (2.37 ± 0.18) was significantly the highest.

At intra-bony component fill (Table 1) there was insignificant difference as P = 0.18, 0.44, and 0.07 regarding G1, G2, and G3 respectively. After 3 months: Group1 (3.97 ± 0.79) was significantly the lowest, group3 (2.27 ± 0.088) was significantly the highest, while group2 (3.16 ± 1.29) demonstrated insignificant difference with other groups. After 6 months: Group1 (3.97 ± 0.8) was significantly the lowest, then group2 (3.13 ± 1.18) and group3 (2.26 ± 0.05) with insignificant difference between them.



Figure(3). CBCT sagittal cut showing linear measurements after therapy: first line (A) length from CEJ: cemento-enamel junction; BD: most apical extension of the bony defect. The second line (B) AC: alveolar crest; BD: most apical extension of the bony defect.



Figure(4). CBCT sagittal cut showing angular measurements of infrabony defect at mesial aspect of lower right first molar after therapy: defect width, angle between root surface and lateral bony wall.

4.Discussion

This study was intended to compare a novel SF nanofiber membrane to CM as a regenerative modalities for treatment of periodontal defects with an intrabony component of ≥6, in parallel with notable advancements in the regenerative treatment of intrabony defects using minimally invasive approaches.[22] To the best of our knowledge, this is the first clinical experiment using SF nanofiber membrane to treat intrabony defects. The subject matter was "For patients with periodontal intrabony defects (P), what is the best used approach (I), comparing MIST, MIST+CM, and MIST+ SF nanofiber membrane to improve intrabony component fill (O)?" .

Regenerative therapy success is largely dependent on space maintenance and clot stability.[23] During the initial stages of healing, the blood clot stability inhibits the epithelial cells' apical migration. Therefore, MIST, with or without the additional benefit of membranes, may improve blood clot stability while accomplishing and preserving primary soft tissue closure, leading to better clinical outcomes. A systematic review and meta-analysis came to the conclusion that conservative surgery can treat intrabony defects with a high rate of tooth retention and improvements in periodontal clinical parameters, even though clinical performance may vary depending on the type of surgical flap used. Periodontists can reduce the possibility of soft-tissue recession and its associated complications by creating flaps with as little alteration to the papillary shape as possible. The correct therapy choice should reduce the amount of the interdental papilla that shrinks or disappears as a result of periodontal therapy. Better outcomes and a safer environment for periodontal regeneration have been attained when employing MIST.[23] This could be explained by main intention-driven wound healing, which reduced the likelihood of clot instability and membrane exfoliation. Additionally, it lessens the chance of the papilla collapsing into the defect and the formation of interdental soft tissue craters, leaving more room for regeneration and simplifying the process of patients maintaining good oral hygiene. It is important to understand, though, that MIST is primarily useful for isolated intrabony defects that permit sufficient access for root-surface and defect debridement while maintaining the interdental papillae and supracrestal soft tissues.

The success of GTR is widely thought to be largely dependent on the wound-stabilizing and space-making capabilities of various membrane types, particularly in difficult defects.[24] According to (Tonetti et al. 1996)[25], the most important predictor of regeneration outcome was the quantity of space under the membrane rather than the entire depth of the intrabony defect. (Trombelli et al. 1997)[26] found no link between defect morphology and gain in probing bone level, which is in line with the latter findings.

With respect to radiographic outcomes, group 2 (MIST with CM) and group 3 (MIST with SF) in the current study saw a statistically significant increase in radiographic defect fill in comparison to group I (MIST alone). The recent results showed that intra-bony component fill was insignificant difference as P = 0.18, 0.44, and 0.07 regarding G1, G2, and G3 respectively Radiographic results in MIST alone have only been published in one trial, and the intrabony defect showed 0.95 mm of bone gain.[27] Different baseline levels and radiographic evaluations may be the cause of the difference between the current results and those from earlier investigations. The more difficult baseline defect used in this study had a detrimental impact on bone growth in intrabony defects treated with MIST, which might not be enough to maintain soft tissue in non-contained periodontal defects on its own. These findings highlight the significance of determining which faults are appropriate for which treatment modalities in order to tailor care and forecast results. As a result, treating these deficiencies with substances that might encourage periodontal regeneration, such as membranes, may be advantageous.

Present data, however, are not as strong as those from a recent meta-analysis[28], which found that utilizing MIST in a surgical approach resulted in a weighted bone gain of 1.9 mm. Notably, considering that these are 6-month results, when analyzed at longer follow-up periods, significant improvements in radiographic intrabony component fill may be seen in all groups. Furthermore, compared to periapical radiography, the use of cone-beam computed tomography imaging provides a more accurate picture of the defect's morphology and depth.

The precision of the radiography technique determines the correct identification of the alveolar bone defects. In most cases, 2D radiographs are not enough to assess intrabony defects in the second and third walls. A number of factors, such as the superimposition of anatomic bone structures or blockage of spongious bone alterations in the cortical plate, could be responsible for this. Images produced were more accurate with the inclusion of a third diagnostic plane, particularly when looking in a buccolingual orientation.[29] As a result, CBCT was used in the current investigation for radiographic assessment of the intrabony defects and the results of the used techniques.

The research suggests that surgical reentry operations are the gold standard because they offer conclusive data on the dimensions and morphology of the infrabony defect both before and after regenerative therapy. Numerous drawbacks accompanied these operations, chief among them being increased morbidity. Actually, without the need for a reentry procedure, the CBCT image in conjunction with the assessment of clinical parameters like attachment levels, clinical probing depths, and levels of alveolar bone may improve our capacity to ascertain the course of treatment after periodontal therapy.[30]

When it comes to diagnosing infra-bony defects and evaluating the effectiveness of regenerative therapies, cone beam computed tomography (CBCT) is a precise and trustworthy method. A high degree of association was found between CBCT and intra-surgical assessments of bone defects when compared to intrasurgical measurement.[31] CBCT and periapical or panoramic images have been used in numerous research to compare intra-bony defects in skulls. It was clear that CBCT provided a better description of infrabony defects than intraoral pictures, coming closest to capturing the true depth of the defect.[32] More research is necessary to provide precise and thorough criteria for the use of CBCT, as some studies have revealed that the technology overestimates the depth of bone defects.[33]

Because of its unique biological characteristics, such as its high oxygen and water vapor permeability, biodegradability, minimal inflammatory response, and good biocompatibility, many researchers have looked into silk-based nanofibers as potential materials for biomedical applications in relation to the SF membrane.[34] In a rabbit calvarial defect model, an SF membrane produced using the casting technique demonstrated a greater capacity for new bone regeneration than an uncovered defect. Additionally, because SF membranes are inexpensive and biocompatible, they can be used as appropriate barrier membranes for GBR even though they have poor mechanical qualities and are challenging to handle.[11,35] Additionally, they have low immunological response and excellent compatibility with osteogenic cells for the formation of new bone.[36] It exhibits equivalent new bone regeneration without an inflammatory response when compared to the collagen membrane.[35]

But in its dry form, the casting SF membrane exhibits more brittleness and poor mechanical qualities. Cell morphology, proliferation, and differentiation can all be impacted by the mechanical characteristics of scaffolds employed in tissue engineering.[37] Before new tissue may form in the scaffold, it must maintain its structural integrity. Despite its potential as a GBR membrane, more biocompatible and biodegradable silk-based membrane scaffolding that is free from the foreign body reaction needs to be created since the structural conformation of silk fiber impacts its mechanical properties.[11]

By applying the electrospinning manufacturing approach in the current work, we attempted to get beyond these restrictions and improved clinical handling as a result. The ability of the electrospinning method to produce ultra-fine fibers or fibrous structures of several polymers with diameters ranging from several micrometers to a few nanometers has drawn interest. For tissue engineering, electrospinning is also utilized to create biopolymer scaffolds, such as electrospun silk nanofiber scaffolds.[38] An aligned, random fiber shape with a surface that encourages cellular adhesion is produced via electrospinning. Periodontal regeneration is preserved because the fibers facilitate matrix deposition and the surface layer inhibits junctional epithelium.[39]

Through the method of electrospinning, silk fibroin can produce nanofibers that mirror the extracellular matrix collagen's effectiveness towards protein and cell response.[10,40] The current study's outcome validates SF's capacity to promote osteogenic cell differentiation, proliferation, and new bone formation. It is also conceivable to speculate that the improved bacterial cleansing of the root surface is connected to the positive clinical outcomes of the current investigation. In order to accomplish periodontal regeneration, this is crucial. Throughout the study, the PI and BoP data provide as evidence for this. Advances in regenerative medicine in recent times have stoked greater interest for these approaches. As a result, it would be advised to carry out further research contrasting SF with various regeneration membrane kinds as an addition to various surgical methods for the therapy of intra-bony defects.

5.Limitations:

The study came to the conclusion that while the formation of the cementum and periodontal ligament is yet unknown, radiographic bone increase implies bone regeneration. Additional re-entry surgery and histologic analysis are needed to validate the efficaciousness of the treatments. Despite its limitations, the study's unique application of SF nanofiber membrane should lead to increased therapeutic applications and a deeper understanding of the healing process.Without making a distinction based on the location of the defect, the study concentrated on defects pertaining to single- and multi-rooted essential teeth in the maxilla or mandible. Improved clinical handling was the outcome of the researchers' usage of the electrospinning manufacturing technology to get around obstacles.

6. Conclusion

Intrabony defects treated by MIST, in conjunction with or without a CM or SF nanofiber membrane, can effectively restore periodontal conditions. With equivalent radiographic results without unfavorable inflammatory reactions, silk fibroin, an alternative to CM, has the potential to be a low-cost and economical therapeutic option for intrabony defects.

Larger trials are required to confirm results and determine which defects benefit most from MIST or MIST plus membrane. When treating intrabony defects, factors such as defect topography, location, experience, patient preferences, and perceived cost should be taken into account.

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Ethical Regulations:

a) The research, therapies, and any possible adverse effects were fully explained to the patients.
b) The patients signed an informed consent. Moreover a verbal approval was obtained for the patient.

Declarations

Ethics approval and consent to participate All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare no competing interests.

7. References

1. Pihlstrom BL, Michalowicz BS, Johnson NW (2005). Periodontal diseases. Lancet. 366:1809-1820.
2. N. Sultan, Zeba Jafri, Madhuri Sawai, Ashu Bhardwaj (2020). Minimally invasive periodontal therapy. Journal of Oral Biology and Craniofacial Research 10. 161–165.
3. Laugisch O, Cosgarea R, Nikou G, Nikolidakis D, Donos N, Salvi GE, Stavropoulos A, Jepsen S, Sculean A (2019). Histologic evidence of periodontal regeneration in furcation defects: a systematic review. Clin Oral Investig. 23:2861–2906.
4. Kao RT, Nares S, Reynolds MA (2015). Periodontal regeneration-intrabony defects: a systematic review from the AAP regeneration workshop. J Periodontol. 86:2:77–104.
5. Nibali, L., Koidou V. P., Nieri M., Barbato L., Pagliaro U. & Cairo F (2020). Regenerative surgery versus access flap for the treatment of intra-bony periodontal defects: A systematic review and meta-analysis. Journal of Clinical Periodontology .47:22:320–351.
6. Marco C. Bottino , Vinoy Thomas , Gudrun Schmidt , Yogesh K. Vohra, et al, (2012). Recent advances in the development of GTR/GBR membranes for periodontal regeneration-A materials perspective. Dental materials: official publication of the Academy of Dental Materials. 28(7):703-721.
7. Gamal AY, Kumper RM (2012). A novel approach to the use of doxycycline-loaded biodegradable membrane and EDTA root surface etching in chronic periodontitis: a randomized clinical trial. J Periodontal. 83(9):1086-94.
8. Walmsley GG, McArdle A, Tevlin R, Momeni A, Atashroo D, Hu MS, Feroze AH, Wong VW, Lorenz PH, Longaker MT, Wan DC (2015). Nanotechnology in bone tissue engineering. Nanomedicine: Nanotechnology, Biology, and Medicine. 1-10.
9. Amiraliyan N, Nouri M, Haghighat Kish M (2010). Structural characterization and mechanical properties of electrospun silk fibroin nanofiber mats. Polymer Science, Ser. A. 52:4:407–412.
10. Kim KH, Jeong L, Park HN, Shin SY, Park WH, Lee SC, Kim TI, Park YJ, Seol YJ, Lee YM, Ku Y, Rhyu IC, Han SB, Chung CP (2005). Biological efficacy of silk fibroin nanofiber membranes for guided bone regeneration. J Biotechnol. 120(3):327-39.
11. Kwang-Jun Kwon and Hyun Seok (2018). Silk Protein-Based Membrane for Guided Bone Regeneration. Appllied Science. 8, 1214
12. Position Paper: Periodontal Regeneration. Journal of Periodontology 2005;76:1601-1622.
13. Nibali, L (2021). Guest editorial: Time to reflect on new evidence about periodontal regenerative surgery of intrabony defects. Journal of Clinical Periodontology. 48:557–559.
14. Cortellini P, Tonetti M. S (2009). Improved wound stability with a modified minimally invasive surgical technique in the regenerative treatment of isolated interdental intrabony defects. J Clinical Periodontology. 36: 157–163.
15. Young-Mi Chung, Jue-Yeon Lee, Seong-Nyum Jeong (2014). Comparative study of two collagen membranes for guided tissue regeneration therapy in periodontal intrabony defects: a randomized clinical trial. J Periodontal Implant Sci.44(4):194–200.
16. Tonetti MS, Greenwell H, Kornman KS (2018). Staging and grading of periodontitis: framework and proposal of a new classification and case definition. J Clin Periodontol. 45: S149- S161.
17. Eickholz P, Hörr T, Klein F, Hassfeld S, Kim TS (2004). Radiographic parameters for prognosis of periodontal healing of infrabony defects: two different definitions of defect depth. J Periodontology. 75(3):399–407.
18. Steffensen B, Webert HP (1989). Relationship between the radiographic periodontal defect angle and healing after treatment. J Periodontology. 60(5):248–254.
19. Wei K, Li Y, Kim KO, Nakagawa Y, Kim BS, Abe K, Chen GQ, Kim IS (2011). Fabrication of nano-hydroxyapatite on electrospun silk fibroin nanofiber and their effects in osteoblastic behavior. J Biomed Mater Res A. 97(3):272-80.
20. Newman MG, Takei H, Klokkevold PR, Carranza FA (2011). Carranza's clinical periodontology. Elsevier Health Sciences; 2011.
21. Fournier BP, Larjava H, Hakkinen L (2013). Gingiva as a source of stem cells with therapeutic potential. Stem Cells Dev. 22:3157-3177.
22. Stavropoulos A, Bertl K, Spineli LM, Sculean A, Cortellini P, Tonetti M (2021). Medium- and long-term clinical benefits of periodontal regenerative/reconstructive procedures in intrabony defects: Systematic

review and network meta-analysis of randomized controlled clinical studies. J Clin Periodontol. 48(3):410–30.

23. Cortellini, P (2012). Minimally invasive surgical techniques in periodontal regeneration. J. Evid.-Based Dent. Pract. 12, 89–100.
24. Sigurdsson TJ, Hardwick R, Bogle GC, Wikesjo¨ UM (1994). Periodontal repair in dogs: Space provision by reinforced ePTFE membranes enhances bone and cementum regeneration in large supraalveolar defects. J Periodontol. 65:350-356.
25. Tonetti MS, Prato GP, Cortellini P (1996). Factors affecting the healing response of intrabony defects following guided tissue regeneration and access flap surgery.J Clin Periodontol. 23:548-556.
26. Trombelli L, Kim CK, Zimmerman GJ, Wikesjo¨ UM (1997). Retrospective analysis of factors related to clinical outcome of guided tissue regeneration procedures in intrabony defects. J Clin Periodontol. 24:366-371.
27. Ribeiro, F.V.; Casarin, R.C.; Júnior, F.H.; Sallum, E.A.; Casati, M.Z (2011). The role of enamel matrix derivative protein in minimally invasive surgery in treating intrabony defects in single-rooted teeth: A randomized clinical trial. J. Periodontol. 82, 522–532.
28. Barbato, L.; Selvaggi, F.; Kalemaj, Z.; Buti, J.; Bendinelli, E.; Marca, M.; Cairo, F (2020). Clinical efficacy of minimally invasive surgical (MIS) and non-surgical (MINST) treatments of periodontal intra-bony defect. A systematic review and network meta-analysis of RCT's. Clin. Oral Investig. 24, 1125–1135.
29. Braun X, Ritter L, Jervøe-Storm PM, Frentzen M (2014). Diagnostic accuracy of CBCT for periodontal lesions. Clin Oral Investig. 18: 1229–36.
30. Grimard BA, Hoidal MJ, Mills MP, Mellonig JT, Nummikoski PV, Mealey BL (2009). Comparison of clinical, periapical radiograph, and cone-beam volume tomography measurement techniques for assessing bone level changes following regenerative periodontal therapy. J Periodontal 80:48-55.
31. Seraj M Keibah, Abdel-Fattah M Amer and Mohammed F Khedr (2017). Comparison Between Cone-Beam Computed Tomography And Intraoral Radiography To Diagnosis Periodontal-Bone Defect And Treatment Response. Al-Azhar Journal of Dental Science. 20, 2,129-137.
32. B. Vandenberghe, R. Jacobs, and J. Yang (2008). Detection of periodontal bone loss using digital intraoral and cone beam computed tomography images: an in vitro assessment of bony and/or infrabony defects," Dentomaxillofacial Radiology. 37, 5,252–260.
33. Clemens Walter, Julia C. Schmidt, Carin A. Rinne, Silwan Mendes, Karl Dula & Anton Sculean (2020). Cone beam computed tomography (CBCT) for diagnosis and treatment planning in periodontology: systematic review update.Clinical Oral Investigations. 24:2943–2958.
34. Lorenz Meinel, Vassilis Karageorgiou, Sandra Hofmann, et al (2004). Engineering bone-like tissue in vitro using human bone marrow stem cells and silk scaffolds. J. Biomed. Mater. Res. 71A,1, 25-34.
35. Kim, J.Y., Yang, B.E., Ahn, J.H., Park, S.O., Shim, H.W (2014). Comparable efficacy of silk fibroin with the collagen membranes for guided bone regeneration in rat calvarial defects. J. Adv. Prosthodont. 6, 539–546.
36. Song, J.Y., Kim, S.G., Lee, J.W., Chae, W.S., Kweon, H., Jo, Y.Y., Lee, K.G., Lee, Y.C., Choi, J.Y., Kim, J.Y (2011). Accelerated healing with the use of a silk fibroin membrane for the guided bone regeneration technique. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. 112, e26–e33.
37. Jeffrey A. Hubbell (1995). Biomaterials in Tissue Engineering. Biotechnology.13, 565–576.
38. Mengyan Li a, Mark J. Mondrinos a, Milind R. Gandhi, et al (2005). Electrospun protein fibers as matrices for tissue engineering. Biomaterials. 26, 30, 5999-6008.
39. Qasim, S.B.; Najeeb, S.; Delaine-Smith, R.M.; Rawlinson, A.; Rehman, I.U (2017). Potential of electrospun chitosan fibers as a surface layer in functionally graded GTR membrane for periodontal regeneration. Dent. Mater. 33, 71–83.
40. Zhang, J.-G.; Mo, X.-M (2013). Current research on electrospinning of silk fibroin and its blends with natural and synthetic biodegradable polymers. Front. Mater. Sci. 7, 129–142.

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