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Using Membranes for Socket Preservation: Biological Concept, Classification, Resorption and Compared Results

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ABSTRACT

Introduction: *This systematic review was performed to study the indication of membranes for guided bone regeneration during extraction, with its limitations and the properties.*

Material and methods: *A thorough Pubmed and cochrane database search were performed on related keys words associated with the subject. Many titles and selected abstracts were independently screened, followed by full text evalutation of different meta-analysis, literature review and comparative clinical trial.*

***Results**: The membrane's use started during 60's until now. Today, the proprietes of membrane are well known. The resorption and efficacity depends of membrane's composition, exposition risk, volume and morphology of reconstruction. This last consideration should guide the membrane's choice.*

***Conclusion:** This littérature review draws the membranes biologic proprieties like biocompatibility, bio integration, clot stabilisation, cellular barrier…*

The advantage and inconvenient of each kind of membranes was studied, and the main results was compared in order to choose the best material regarding the indication.

Introduction

The alveolar, cancellous bone surrounding the tooth must remain present in sufficient quantity and quality to carry out implant-supported rehabilitation.

Indeed, the loss of alveolar bone caused by tooth loss, often requires the practitioner to perform bone reconstruction by invasive, complex and sometimes non aesthetics techniques, and this for the only purpose of ensuring correct bone support to place the implants, and ensure their durability.

Taken in time, preservation via alveolar preservation techniques such as guided bone regeneration, ensures a sufficient volume that meets the criteria for implant success, and this without using invasive and complex techniques.

Alveolar preservation is defined as any procedure undertaken at or after extraction, with the aim of minimizing resorption of alveolar bone and maximizing bone formation (1).

Its objective is both to limit the vertical and horizontal loss of the alveolar ridge (2).

Its placement can be done at different times, especially during and after tooth extraction. However, placement during extraction surgery can limit the number of operations and reduce treatment time.

We propose here to study the interest of membrane for guided bone regeneration during extraction, with its limitations. We will see the properties of the different elements used as well as their effectiveness.

Material and Methods

This work is based on a review of the literature in the Pubmed and Cochrane database

The keywords used for the search are:

- Socket preservation
- Guided bone regeneration
- Bone resorption
- Membranes
- Bone substitutes materials
- Tooth extraction
- Dental implant
- Socket filling
- Dehiscence / fenestration

The inclusion criteria are:

- Meta analysis : high level of evidence
- Comparative analysis
- Retrospective study
- Prospective clinical trial
- Case report (low level of evidence)

The exclusion criteria are:

- Article greater than 10 years except for historical study

Number of articles included:

- More than 30 articles analyzed.
- 13 studies included in this thesis

The result is classified on different parts to facilitate reading

Results

History and concept evolution

Historical study and discovery of periodontal healing

In 1968, Hiatt (1) sought to know the mechanism of flap's attachment. He uses 16 dogs with periodontal pockets greater than 4mm. He makes a mucoperiosteal flap with 2 vertical discharge incisions. The sites are scaled, then the flap repositioned under digital pressure for 2 minutes. Two sutures point are done to hold the flap. Dogs are sacrificed on days: 2, 3, 7, weeks 2, 3, 4, and months 4, 6, 12. Before the dog dies, the sutures are removed, and a pressure monitor is used to measure the force required to detach the healing flap. After the dogs die, a histological study is performed to understand the principles of wound healing.

Here are the numerical results of the flap resistance (force required to separate the flap):

Time	J2	J3	J7	J14
Force needed to detach the flap	225g	225g	340g	1.7kg

On the 7th day, the resistance of the flap is made by epithelial healing. Beyond 1 month, it is no possible to completely separate the flap from the tooth: traction produces an epithelial tear in the traction area, but no flap lift.

-Histological analysis of epithelial healing:

During the first 3 days, the fibrin clot and blood elements prevent epithelial attachment, but after a week it appears normal. Histologically, an epithelial migration is observed towards the center of the flap, but without adhesion to the dental tissues. It takes 2 weeks to find histological evidence of epithelium / root surface connection. The values recorded with the tensiometer furthermore prove these histological results. The dog sacrificed at 6 months, indicates an epithelial stress zone on the traction zone, but without any damage to the epithelium / tooth junction. After 1 year, an epithelial recession is quantified at 1 to 3mm, with an epithelium infiltrated with inflammatory cells.

We conclude that the epithelium invaginates within the healing clot as early as 7 days. From 15 days, an attachment is made between the root tissue and the epithelium, increasing the resistance of the flap.

-Histological analysis of connective tissue healing:

Between days 2 and 3, the connective tissue is separated by the fibrin layer, which is thicker at the apical aspect. Blood supply from the alveolar bone and periodontium enters the clot. Within 2 weeks, connective tissue proliferation progresses and resorbs the fibrin clot. From 4 weeks, the proliferation of connective tissue is considered important and ensures attachment to the root surfaces.

We conclude that the connective tissue proliferates from the 2nd week, and attains sufficient attachment from 4 weeks.

-Histological analysis of bone and cementum healing:

The presence of osteoclasts is noticed at the 3rd week and leads in 1 month to 1mm of vertical loss. Simultaneously on the periphery, a new bone formation is observed.

Cemental healing begins at 3 weeks with resorption of the curetted dentin. Between the 4th week and the 6th month, a continuous formation of cementum is observed, leading to the surface repair of the resorbed dentin.We conclude that bone and cemental healing begins at 3 weeks. Cementation training is long, requiring several months.

Melcher in 1976 (2) tells us that the healing process (regeneration or repair) will be determined by the cellular colonization of the healing area. In view of Hiatt's study (1) , we then understand that the epithelial cells, colonizing the site as early as 7 days, will cause epithelial repair of the area, and not regeneration of the bone and cement, because of their slow migration. We will see later, what techniques were used to block this epithelial migration, and let the bone cells colonize the site.

Membrane and their interest development

In 1974 Goerge winter (3) used PTFE to set up the first cellular barriers without immune reaction. In 1982, Winter (4) continued on these discoveries and carried out in vivo models in dogs. In addition to the already known cell blockage, it highlights connective attachment to the membrane and stabilization of the clot.

The same year, Nyman and Lindhe (5), in monkeys, analyzed healing after scarification and membrane used under flap for cell exclusion. In addition to the absence of epithelial cells, they note bone and cement regeneration, with functionally oriented periodontal fibers. This is where the notion of guided tissue regeneration was born.

They then repeat this experience in humans (6), on an incisor affected by periodontitis, with a similar result.

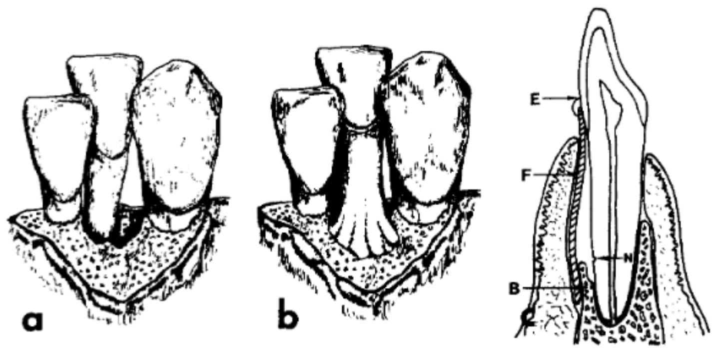

Figure 2: Representation of Nyman's human experimentation (6)

In 1985, Gore (4) sought to improve the clinical workability of membranes, which had been difficult until now. He develops an in vivo model (in dogs) with a flexible part and a rigid and adaptable part. The clinical efficacy is demonstrated after sacrifice of the dogs at 3 months.

The use of membranes in conjunction with implant techniques appeared in 1988. Very quickly, the authors understood that cell exclusion wasn't the only issue. Thus the available and maintained volume will give rise to an expected volume of bone regeneration (7). The membrane must be rigid, retain its mechanical properties, and prevent the flap from collapsing.

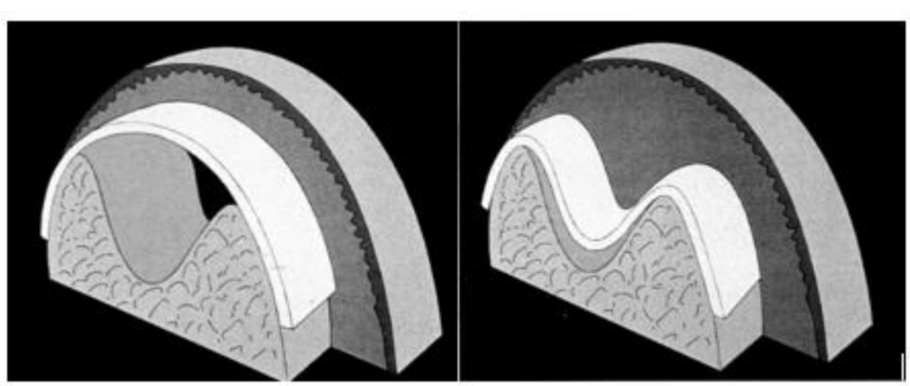

Figure 3: illustration of space maintenance necessity with membrane regidity (4)

The biomaterials that we will describe in the next section are a help in maintaining space, and a support for the membrane.

The materials constituting the membranes have evolved, and a wide range is now available to the practitioner. To avoid a removal intervention, absorbable membranes have appeared. Their properties depend on their origin and will determine their indications. We intend to describe this in the next section.

Resorption rate of resorbable membranes

In 2005, Rothamel (8) investigated the different degradations of collagen membranes. He seeks to compare the degradation of simple collagen structure with cross-linked collagen.

It tests 5 commercials membranes: Biogide (porcine collagen I and III), Biomend (simple bovine collagen I), Biomend extend (cross-collagen I), Ossix (cross-bovine collagen I), Tutodent (simple bovine collagen I); and 3 type I and III cross-collagen experimental membranes called VN1 VN2 VN3.

The membranes are placed in the dorsal muscle of 40 rats. These rats are classified into 5 groups corresponding to the times of their sacrifice: 2, 4, 8, 16, 24 weeks. Each group is made up of 8 rats, so 1 rat per membrane.

After each sacrifice, a histological study and measurement of the membrane thickness are made.

The variation in the thickness of the membranes is given below:

Membrane	**Biogide**	**Biomend**	**Biomend Extend**	**Ossix**	**Tutodent**	**VN1**	**VN2**	**VN3**
Composition	Col I, III	Col I	Col I	Col I	Col I	Col I,III	Col I,III	Col I,III
Cross Structure	No	No	Yes	Yes	No	Yes	Yes	Yes
Origin	Porcine	Bovine	Bovine	Bovine	Bovine	Porcine	Porcine	Porcine
2 weeks	800µm	700µm	1100µm	300µm	700µm	600µm	600µm	450µm
4 weeks	300µm	650µm	1100µm	300µm	700µm	450µm	500µm	550µm
8 weeks	100µm	100µm	100µm	300µm	500µm	200µm	350µm	400µm
16 weeks	100µm	150µm	100µm	250µm	250µm	150µm	200µm	200µm
24 weeks	150µm	100µm	100µm	250µm	250µm	150µm	100µm	250µm

Through these results we understand that:

- The Biogide is quickly degraded: its thickness is greatly reduced from 4 weeks.
- Resorption of Biomend membranes is stable for up to 4 weeks, then massive between weeks 4 and 8. No real difference between dense and simple structure.
- The Ossix membrane seems to be very weakly resorbed at 24 weeks, so its structure is maintained over time.

- The Tutodent membranes, VN1 VN2 VN3 gradually degrade until week 16, reaching a thin thickness at week 24.

It seems that out of the 8 membranes, 5 retain their structure for up to 8 weeks. Of these 5 membranes, 4 have a dense, cross-collagen structure. It should be remembered that the studies by Hiatt 1968 (9) and Melcher 1976 (10) indicate the onset of bone healing at 4 weeks. The 3 membranes which are rapidly resorbed therefore seem to lose most of their structure before the onset of bone healing.

Long-term stability appears to be a weak point for some absorbable membranes.

The histological results are shown below:

Membrane	Biogide	Biomend	biomendE	Ossix	Tutodent	VN1 VN2 VN3
Initial microsc opi-que structure	Porous connexion structure	Laminate with wide gap	Laminate with wide gap	Dense structure with interstice	Porous connexion structure	
2 weeks	Full vascularizat°	fine vascularizat°	fine vascularizat°	No vascularizat°	half vascularized	
4 weeks	Almost complete degradation	Complete vascularizat°	Complete vascularisat°	No vascularizat°	Complete vascularization	Fine inflammation
8 weeks		Almost complete degradation	Almost complete degradation	No vascularizat°	Fine inflammation	Fine inflammation
16 weeks				No vascularizat°	Appearance of polynuclear cells.	Complete vascularizat°
24 weeks				Appearance of surface vascularizat°	Almost complete degradation	Almost complete degradation

Histological results confirm measurements of membrane thickness. Depending on the structure and the origin, the architectural maintenance varies over time. This can be problematic for some type of membrane, which absorbs too quickly to ensure its long-term cell barrier function.

Comparaison absorbable and non absorbable membrane

In 2014, Schneider (11) published a multicenteric randomized study evaluating the clinical, histological and radiological results of GBR with a resorbable or non-resorbable membrane.

The study involved 40 patients (mean age 44.6 years) requiring implant placement in the presence of a bone defect. A total of 26 implants are placed in the maxilla, and 14 in the mandible. After a hygienic phase, implant placement is placed by lifting a full thickness flap. Before GBR, bone defect measurements are made (height, depth, width). The test group receives a PGLA (Biodegradable) membrane (59% anterior implants, 41% posterior), and the group controls an ePTFE (Gore Tex) membrane (54% anterior implants, 46% posterior). The bone substitute used is Bio oss. After GBR, the bone table thickness is measured. The patients are followed every month, and at 6 months, the site is opened, the measurements taken and a biopsy were performed.

Here are the average clinical results:

Mesure	Hight of socket defect			Deep of socket defect			Width of socket defect			Width of socket after GBR		
Time	DO	6months	Δ	DO	6month	Δ	DO	6month	Δ	DO	6month	Δ
Test (mm)	6.3	1.2	-5.1	1.1	0.3	-0.8	2.3	0.2	-2.1	3.2	1.4	-1.7
Control (mm)	7.2	0.3	-6.9	1.2	0.1	-1.1	2.5	0.0	-2.5	3.3	2.5	-0.8

There does not appear to be any significant difference in the effectiveness of GBR for the depth and width of the intraosseous defect. The resorbable membrane then appears to be as effective as the non-resorbable membrane in the healing of intraosseous defects. However, the bone gain is significantly higher with regard to the height of the dehiscence and the alveolar width with the use of the non resorbable membrane.

The histological results are based on 29 biopsies (the 11 remaining biopsies cannot be used): 16 controls and 13 tests. Histological evidence for biooss degradation is very limited, as only 2/13 and 2/16 sites indicate resorption of the material at 6 months.

For the test group, no trace of membrane was detected in the biopsies, but macrophages were present, indicating a moderate inflammatory reaction. One site indicates a significant granulomatous reaction.

For the control group, one site indicates membrane exposure accompanied by soft tissue dehiscence. In 3 sites, moderate inflammation is present. And in 6 sites we observe fibrous tissue. No membrane debris was found.

The average histomorphometric results are as follows:

Mesure	Total bone density	Mineralized tissu proportion	Pourcentage of contact: new bone/graft
test	39.9%	64%	48.5%
control	39.8%	57%	44.3%

No significant difference was noted in the total bone density, the proportion of mineralized tissue or the percentage of bone / graft contact.

In this study, the absorbable membrane appeared to be as effective as the non-absorbable membrane in the management of intraosseous defects, and had the advantage of not requiring a second intervention.

The non absorbable membrane remains in this study more effective for horizontal and vertical alveolar augmentation.

Actual classification: advantage and limits

In 2014, Hämmerle and Benic (12) published a review of the literature in which they reviewed the concepts and interest of guided bone regeneration in implantology. Through it, they come back to the advantages and disadvantages of different materials. We propose to come back to their wording to provide a summary table:

Classification	**resorbable**			**Non resorbable**	
Membrane	Biologic	Synthetic	Polymerizable	Expanded	Titane Renforced
Composition	Collagen	Polylactic Acid Polyglycolic Acid	Polyethylen glycol	PTFE	PTFE
Mean avantages	-One surgical procedure -Stabilizable by the healing screw -Resorbable without a foreign body reaction -Fast vascularizat° -Spontaneous epithelialisat ° if exposed	-One surgical procedure -Stabilizable by the healing screw - Resorbable without a foreign body reaction -Fast vascularizat° -Spontaneous epithelialisat ° if exposed	-One surgical procedure -Stabilizable by the healing screw - Resorbable without a foreign body reaction -Fast vascularizat° -Spontaneous epithelialisat ° if exposed -No manipulat° -Easy to use	- absence of immune reaction -long term stability -stabilizable by screws or pins -mechanical property	
					-Rigidity even without the support of the adjacent bone. -Usable for large volumes

Mean limits	-Low mechanical property in the absence of support by biomaterials - No long-term stability (except dense and cross-linked collagen) -difficult to use	- Degradation by reaction to the foreign body -Low mechanical property in the absence of support by biomaterials	-Low mechanical property in the absence of support by biomaterials -No long-term stability	- two surgicals procedures -no spontaneous epithelialization - rapid bacterial colonization if exposed

Conclusion

The progressive evolution of the concept of guided bone regeneration (GBR) has allowed the role of the membrane to be developed and targeted. To ensure effective alveolar preservation, the membrane must:

- Be biocompatible
- Integrate into the healing site
- Stabilize the blood clot
- Be a tight cellular barrier
- Allow the passage of fluid and nutrients
- Be easy to use and adaptable to the site
- Be rigid enough to maintain space

Absorbable membranes require only one operation, and thus avoid additional bone exposure. Collagen absorbs without any reaction to foreign bodies, and the appearance of cross-linked collagen networks helps prolong its stability in the longer term. When adjacent bone provides architectural support and the membrane is held together by biomaterials, then space is conserved and alveolar preservation will occur effectively. However, when the adjacent bone does not support the membrane, or the volume to be preserved is large, the rigidity and mechanical properties of non absorbable membranes become a considerable avantage. Their biocompatibility ensures the absence of tissue reaction, even in case of a long stay on the site. They therefore allow alveolar preservation in the very long term.

References

1. Hiatt WH, Stallard RE, Butler ED, Badgett B. Repair following mucoperiosteal flap surgery with full gingival retention. J Periodontol. janv 1968;39(1):11-6.

2. Melcher AH. On the repair potential of periodontal tissues. J Periodontol. mai 1976;47(5):256-60.

3. Winter GD. Transcutaneous implants: reactions of the skin-implant interface. J Biomed Mater Res. 1974;8(3):99-113.

4. Scantlebury TV. 1982-1992: a decade of technology development for guided tissue regeneration. J Periodontol. nov 1993;64(11 Suppl):1129-37.

5. Nyman S, Gottlow J, Karring T, Lindhe J. The regenerative potential of the periodontal ligament. An experimental study in the monkey. J Clin Periodontol. mai 1982;9(3):257-65.

6. Nyman S, Lindhe J, Karring T, Rylander H. New attachment following surgical treatment of human periodontal disease. J Clin Periodontol. juill 1982;9(4):290-6.

7. Ashish Verma, Dimple Grover, Swati Sanghi, Preeti Upadhyay, Ramavati Mishra, Ashish Verma. Guided Tissue Regeneration – Principles Revisited. Indian J Dent Sci [Internet]. sept 2013 [cité 20 avr 2016];Vol.:5. Disponible sur: http://ijds.in/article-pdf-ASHISH_KUMAR_DIMPLE_GROVER_SWATI_SANGHI_PREETI_UPA-496.pdf

8. Rothamel D, Schwarz F, Sager M, Herten M, Sculean A, Becker J. Biodegradation of differently cross-linked collagen membranes: an experimental study in the rat. Clin Oral Implants Res. juin 2005;16(3):369-78.

9. Hiatt WH, Stallard RE, Butler ED, Badgett B. Repair following mucoperiosteal flap surgery with full gingival retention. J Periodontol. janv 1968;39(1):11-6.

10. Melcher AH. On the repair potential of periodontal tissues. J Periodontol. mai 1976;47(5):256-60.

11. Schneider D, Weber FE, Grunder U, Andreoni C, Burkhardt R, Jung RE. A randomized controlled clinical multicenter trial comparing the clinical and histological performance of a new, modified polylactide-co-glycolide acid membrane to an expanded polytetrafluorethylene membrane in guided bone regeneration procedures. Clin Oral Implants Res. févr 2014;25(2):150-8.

12. Benic GI, Hämmerle CHF. Horizontal bone augmentation by means of guided bone regeneration. Periodontol 2000. oct 2014;66(1):13-40.