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Original Research Paper

Periodontology

COMPARATIVE EVALUATION OF MTA AND BIOACTIVE GLASS IN THE MANAGEMENT OF FURCATION DEFECTS : A CLINICO-RADIOLOGICAL STUDY

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ABSTRACT In regenerative periodontal therapy, various novel material has been used to predictably achieve true periodontal regeneration. In this study, MTA, i.e. Mineral trioxide aggregate has been used in Hamp's degree II furcation defects in Test Group and in Control Group, bioactive glass was used. From the result of this study, it could be assessed that Hamp's degree II furcation defects treated by MTA and Bioactive glass, both demonstrated a significant improvement in the pocket probing depth and clinical attached level at 6 months post-surgery. In both the groups, a statistically significant improvements in both clinical and radiologic parameter from Day 0 to 6 month was evident.

KEYWORDS : MTA, Mineral Trioxide Aggregate, Bioactive Glass, Furcation Defect, Regenerative Periodontal Therapy

INTRODUCTION:

Periodontal disease, a multi-factorial, chronic inflammatory disease, results in progressive loss of attachment of the connective tissue and destruction of supporting alveolar bone of the periodontium. [1] Progression of periodontitis, results in vertical and horizontal bone loss, and leads to formation of various osseous deformities, of which, furcation involvement, poses a clinical challenge.

The goal of periodontal therapy is arresting the progression of periodontal destruction and regeneration of the lost structures. Conventional periodontal therapy focuses at the repair of the diseased periodontium rather than regeneration of the lost tissues. [2] Achieving true periodontal regeneration is considered as the ultimate challenge of the periodontal therapy. For this purpose, different types of graft materials are used. All of these graft materials have certain advantages over the other and there are associated drawbacks. Researchers have never stalled the search for newer materials that would result in the regeneration of the periodontal tissues. Among all the structures of periodontal tissues, cementogenesis has been found to be critically important. [3]

Torabinejad et al. first introduced Mineral trioxide aggregate (MTA) in the year **1993** at Loma Linda University and U.S. FDA approved its use in 1998. [4] During the period of the Mid 90s', several in vivo & in vitro researches, conducted on MTA, have indicated that MTA has a favourable histologic response on cementogenesis and osteogenesis. Since its inception in dentistry, Mineral trioxide aggregate (MTA) gradually gained popularity, to be one of the most promising materials to be used in the management of perforation sites or other communication pathways between pulp chamber and periodontium. [5]

MTA is a fine hydrophilic powder, composed of Portland cement (Tricalcium silicate, Dicalcium silicate, Tricalcium aluminate, Tetracalcium aluminoferite, Gypsum), Bismuth oxide and a trace amount of SiO_2, CaO, MgO [6].

In **2013**, in a systematic review titled "Histological responses of the periodontium to MTA" by **Katsamakis et al.** [7] demonstrated positive outcomes of biocompatibility and cementogenic ability of the MTA. Several in vitro studies depicted ability of MTA, promoting healing towards regeneration. **Perinpanayagam** [8] showed that osteoblasts attach and spread out on the surface of MTA within 24 hours and form a collagenous matrix over it within 1 week. **Zhu** [9] also reported that osteoblasts get attached on MTA surface by forming a monolayer. **Ghanbari et al** [10] reported the use of MTA as a graft material in periodontal osseous defects.

The survey of the literature indicates that there is very limited information available regarding the use of MTA as a graft material, in well-controlled human clinical trial. Considering this, the present clinical research was conceived, in which Hamp's Degree II furcation defects (i.e. horizontal loss of periodontal tissue support, exceeding 3 mm, but not encompassing the total width of the furcation) were treated with MTA as a graft material with GTR membrane.

Following evaluation of different commercially available graft materials, bioactive glass was selected as material to be used in the 'Control Group' due to its time-tested efficacy in periodontal regenerative therapy and ease of availability. A material can be called as 'bioactive', if it elicits an appropriate biologic response and results in the formation of a bond between the material and the living tissues. **Larry. L. Hench (1969)** developed 45S5 Bioglass at the University of Florida. The traditional composition of bioactive glass includes - Na_2O, P_2O_5, SiO_2, and CaO. Since its discovery, different studies are conducted to explore different avenues of its use and in 1993, Bioglass particulate was first used in the infrabony defects. Bioactive glass, when exposed to body fluids, undergoes a series of chemical reactions in its surface, which results in the formation of a

hydroxycarbonate apatite (HCA) layer. During the formation of HCA layer, osteoblasts and organic ground substance, like glycosaminoglycan, get incorporated and the organic matrix is laid down, which undergoes mineralization with time.

Following evaluation of the outcome of different similar pre-clinical studies, this study received ethical approval from the ethics committee of Dr. R. Ahmed Dental College & Hospital, Kolkata. This present study was conducted, to explore whether MTA has any regenerative potential as a graft material, in the management of Hamp's Degree II furcation defects and to comparatively evaluate (both clinically and radiologically), the efficacy of MTA as graft material with a conventional graft material, such as – Bioactive glass.

MATERIALS AND METHODS:

A total of 24 sites from 9 systemically healthy patients (age group- 18-65 years) with chronic periodontitis, with at least one, clinically and radiographically detectable furcation defects and probing depth >5 mm, were selected. Subjects, incapable of maintaining adequate oral hygiene (Silness and Löe 1964, plaque score >1) or with any deleterious oral habits or subjects with any systemic diseases, were excluded. Subjects were enrolled in the study; following signing informed consent. Subjects with furcation defects were divided into two groups. Group A (n = 12): in which the defect site was treated with MTA, with a biodegradable membrane (PerioCol™ – GTR). Group B (n = 12): Defect site was treated with bioactive glass, with biodegradable membrane. Prior to the study, routine blood investigations were carried out. Each subject received phase–I therapy and occlusal adjustment was done. A prefabricated and customized acrylic stent were kept in position while the periodontal probe was inserted into the pocket (i.e. the future surgical site) to reach the deepest portion of the periodontal pocket. A mark was made in the position where the probe and the prefabricated acrylic stent contacted each other and following which using a cylindrical low speed bur, a groove was marked on the acrylic stent to standardize the reference point.

Using the groove as guide, the periodontal probe, i.e. UNC-15, was inserted into the pocket for recording measurements, nearest to the millimeter, in a reproducible manner. **(Fig. 1).** The clinical parameter that were assessed are - Gingival Index (Löe & Silness, 1963), Plaque Index (Silness & Löe, 1964), Clinical attachment level, Probing pocket depth, Furcation involvement detection by Naber's probe. All the clinical measurements were recorded by a single examiner only, to avoid bias and inter-examiner variation.

For recording of the radiographic parameter, standardized IOPA radiographs with 1 sq. mm grid, of the site were taken at baseline, 1 month, 3 months & 6 months postoperatively. Radiographic depth of the furcation defect (RM-F). RM-F was calculated by measuring the linear distance, in mm, from the coronal most extension of the radiopaque crest to the apical most extension of the furcation defect. It was measured by subtracting the linear distance of CEJ to the crest of the bone, from the linear distance of CEJ to the base of the bone defect. Assessment was done, at the level of the bone at mesial, distal & furcation region. **(Fig. 2)**

Prior to the surgery, all the instruments used in the surgery were sterilized by autoclaving (temperature 121°C at 15 psi pressure for 15 minutes). Perioral scrubbing with 5% povidone iodine solution was done and subjects were asked to rinse with 0.2% Chlorhexidine.

The surgical procedure was performed under local anesthesia with 2% lignocaine hydrochloride containing adrenaline at a concentration of 1:80,000. Crevicular incisions were placed, after that full-thickness flaps were raised till the level of furcation defect or till the level of associated bone defect, if present. Debridement and root planing were done with hand instruments (Gracey curettes, Universal curettes, Furcation curette). After properly cleaning the area, the surgical site was carefully irrigated with sterile saline. The graft material (MTA or Bioactive Glass) was emptied into a sterile dapen dish and was mixed with 5-6 drops of sterile normal saline. Graft material was incrementally added and after that it was condensed with a suitable instrument until the defect was completely filled. Resorbable collagen membrane was placed over the grafted site and was secured with sling suture using 4-0 absorbable suture. The flap was then repositioned at the original level and closed with interrupted suture using 3-0 silk sutures **(Fig. 3-7).** Instructions were given to all the subjects as a part of their postoperative regimen. The patients were advised to rinse with 10 ml of 0.2% chlorhexidine mouth wash twice daily for 15 days to help plaque control. They were advised to avoid chewing on the surgical site and were instructed to follow suitable brushing technique at the surgical site. The medications prescribed were antibiotics (Cap. Amoxicillin- 500 mg - TDPC for 5 days) and analgesics (Tab. Paracetamol – 650 mg- S.O.S on pain) and proton pump inhibitors (Tab Pantoprazole – 40 mg, one tab ODAC for 5 days). Postoperative follow up were done after 72 hours and then the patients were recalled after 7 days for periodontal pack and suture removal and for follow up visits at 1 month, 3 months & 6 months interval or in case of any issues as reported by the patients.

Statistical Analysis Plan:

Normality of continuous variables was evaluated by **Kolmogorov-Smirnov Test**. Data were summarized by using means and Standard deviation (SD). An unpaired two tailed t test was undertaken to find out significant difference between two groups. A paired two tailed t test was performed to find out significant outcome of treatment for 180 days as compared to pre-treatment condition (day '0') with Bioactive glass and MTA. Further, Receiver Operating Characteristic (ROC) was performed to find out the area under the curve (AUC) for treatment outcome using above substances in respect to Radiologic measurement at Furcation region (i.e. RM-F) and Clinical attachment level (CAL). A value of '$p' < 0.05$ was considered as statistically significant. The statistical analyses were performed using statistical software Graph pad prism (Version 5, 2007, San Diego, CA, USA).

Results & Observations:

Intra-group and Inter-group comparison of all the soft tissue parameters and hard tissue parameter data at baseline and at 1,3 & 6 months, post –surgery, are presented in **Chart 1-6**.

DISCUSSION:

Different studies suggest evidence of regeneration of periodontium, in the sites where proper graft material, membrane, and their combinations were used in different well-controlled clinical trials.

The primary objective of this present study was to clinically and radiologically evaluate the efficacy of MTA as an alloplastic graft material in Hamp's Degree II furcation defects and the other objective was to compare the outcome, with the efficacy with another alloplastic graft material, i.e. bioactive glass.

A graft material not only provides osteoinductive or osteoconductive capacity for regeneration, but it also maintains the space. The superiority of the combination of

bone graft and GTR membrane, over open flap debridement alone is already been established in AAP CONSENSUS Report.[11] Study conducted by Novaes AB et al.[12] reported that the combination of bone graft with GTR membrane yielded better results when compared to open flap debridement in the management of Grade II furcation defects. Hence, in this study to compare the effectiveness of MTA, a bone graft material (i.e. the bioactive glass) with GTR membrane was considered, rather than considering open flap debridement as the control group.

It is difficult to control different factors that could affect the outcomes of regeneration therapy of furcation defects; which include the oral hygiene, smoking, occlusal loads, pulpal status and furcation-related factors such as root divergence or root trunk length[13]. In the present study, an attempt was made to control and exclude the confounding variables; therefore, smokers and teeth with endodontic and pulpal involvement were excluded.

The physical characteristics of the graft materials are of paramount importance as the particle size and the pore size play a crucial role in osteoconductivity of bone replacement graft material. The size of particles of the bioactive glass ranged from 300 - 350 microns. **Granito et al.**[14] reported of favorable tissue response associated with 300-355 microns particles, which led to bone regeneration and deposition in the damaged periodontium.

Regarding consideration on material manipulation characteristics, the bioactive glass was comparatively easy to prepare and place. It formed a cohesive mass when mixed with saline and did not show any tendency to flow due to bleeding and/or presence of saliva, GCF. Studies[15] reported that it has the potential to act as a haemostatic agent and it can maintain the blood clot in the periodontal defects.On the other hand, manipulation and delivery of the MTA was more difficult, as the MTA tends to get washed away by saliva, GCF, blood. Further researches are required in this aspect so that the stability of the MTA can be ensured. Presence of some particles at the flap margins during suture removal and even at 4 weeks after the surgical procedure, were common in both the groups.

During the follow up period, no history of infection, abscess or delayed healing was observed or reported by any patient. This might be attributed to the antibacterial properties of both the materials, as reported in different studies[16,17,18].

In this study, in the MTA Group, the mean probing pocket depth at baseline (i.e. Day 0) was 4.125±0.815 & the mean CAL at baseline was 4.250±1.904 and at 6 month follow up visit the PPD & CAL changed to 2.042±0.81 and 2.250±1.406. On the other hand, in the Bioactive glass Group, the mean PPD and mean CAL at baseline was 3.854±0.98 & 4.986±2.533 respectively, following periodontal surgery, 6 month follow up visit it declined to 1.938±0.622 & 3.104±2.013. In this study, the radiological findings as evident in the grid of the IOPARs are the following: In the Group A, the mean Bone level at the Furcation defect, at baseline was at 1.542±0.62 mm, after 6 months it changed to 1.083±0.469 mm. (Fig. 9). In the Group B, the mean bone levels at the Furcation defect at baseline was 1.625±0.882 mm and at 6 month follow up visit it was at 1.042±0.45 mm.

From this study, it could be assessed that Hamp's degree II furcation defects treated by MTA and Bioactive glass, both demonstrated a significant improvement in the pocket probing depth and clinical attached level at 6 months post-surgery. In both the groups, a statistically significant improvements in both clinical and radiologic parameter from Day 0 to 6 month (i.e. Day 180) was evident. However, no significant difference was observed, in changes in mean clinical attachment level between MTA (4.25±1.90) and Bioactive glass (4.98±2.53) treatment group (p=0.42) as well as in terms of radiological parameter , the MTA (1.54±0.17) and Bioactive glass (1.62±0.25) treatment group showed no significant difference in mean Radiological measurements (RMF) at furcation region values (p=0.79) . This statistical observation indicates that the differences between the two groups at final evaluation were not influenced by the initial differences of characteristics of the defects; thus, the postoperative results could be easily compared.

There is limited information available, to the best of the knowledge of the researcher of this work, regarding any other study related to the efficacy of MTA to treat furcation defects. Therefore, the result of this study was compared to the outcome obtained by the study conducted by **Ghanbari et al.**[10] where pocket depth reduction in the MTA was 4.21 mm.

In both the groups of this present study, improvements in pocket depths were statistically significant compared to the baseline values and the improvement was comparable to each other.

As per Hamp's Classification of Furcation defect, Degree II furcation defect refers to, a defect with a horizontal depth of more than 3 mm and Degree I defect is horizontal defect of ≤3 mm, as evident with examination by Naber's probe. In this study, 91.66% and 100% of the Degree II Furcation defects treated with MTA and Bioactive glass, respectively, were converted to Degree I and none progressed to Degree III. Out of 12 sites in MTA group, only 1 furcation defect remained Degree II.

Lekovic V et al[19]. considered reduction in pocket depth and gain in clinical attachment as important clinical outcomes of regenerative therapy. **Zybutz M et al.**[20] also advocated the significance of clinical and radiographic parameters in assessing the outcome of intrabony defects. Although histological evidence of regeneration of periodontium should be considered as the important most evidence to assess regenerative potential of any treatment modality. In this study, it could not be performed to avoid the chances of inducing alveolar bone loss following re-entry. Hence, in this study, surrogate outcomes such as - changes in pocket probing depth, attachment level and radiological evaluations were considered to assess the outcome of periodontal therapy. Corroboration of gain in clinical attachment level with the gain in radiological alveolar bone level and postsurgical healing with the absence of any adverse complications indicated a favorable soft tissue response in both the groups. However, **Camargo et al.**[21] stated that such improvement in clinical parameters does not necessarily indicate an actual gain in attachment as the presence of the graft material within the defect may modify gingival tissue consistency and therefore may interfere with the penetration of the periodontal probe without necessarily having induced any gain in CAL.

Complete furcation closure, that is, 100% resolution could not be achieved in any of the sites in both the groups. In this study, no furcation was completely filled as there was always some amount of horizontal and vertical component of the furcation lesion present postoperatively. This is in accordance with different other studies[22, 23, 24], having similar outcome of incomplete furcation closure.

Further research with standardization of the numerous factors that influence the regenerative status (i.e. patient

selection, standardization of furcation defect, analysis of defect and furcation characteristics, large sample size, and standardized evaluation methods) would lead to a better comparison of studies with MTA and any other graft material. This would help to indicate the true impact of each factor on the final therapeutic result.

CONCLUSION

From this present clinical study, it can be concluded that the use of MTA results in statistically significant clinical improvement of periodontal parameters as well as improvement of radiological parameter compared to the pretreatment level. Such outcome supports evidence of periodontal regeneration. The improvement of the parameters can be compared with the efficacious outcome as evident in the bioactive glass group. No statistically significant difference between these two groups regarding any of the parameters could be found.

However, in this era of evidence based dentistry, drawing a definite conclusion depending on the direct comparison of clinical results and radiographic findings may not be appropriate. Only well controlled multi-center clinical trials with larger sample size and longer duration of follow up can justify the use of MTA as an alternative for other more expensive regenerative treatment modalities for furcation defects.

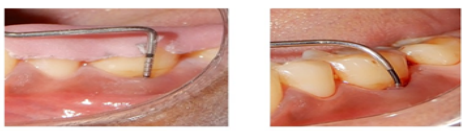


Fig.1 Clinical Examination with UNC – 15 probe with acrylic stent in place and examination with Naber's Probe

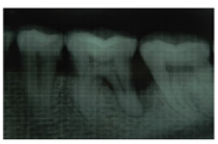
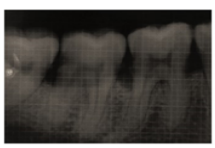


Fig. 2 Intra oral periapical radiographs (IOPAs) with 1 sq mm grid showing furcation involvement and angular bone loss

Fig. 3



Pre-operative (i.e. Baseline) IOPA radiograph with 1 sq. mm grid

Envelope flap was raised and furcation defect was debrided

Placement of MTA

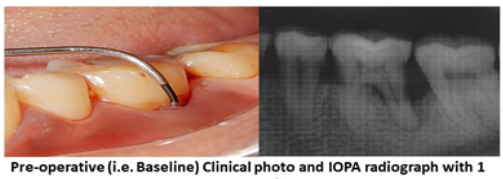
Fig. 4

GTR Membrane placed and secured with Sling suture

Closure of flap

Follow-up clinical evaluation at 6 moths, with Naber's probe

Fig. 5



Pre-operative (i.e. Baseline) Clinical photo and IOPA radiograph with 1 sq. mm grid

Envelope flap raised, debridement of furcation defect done

Placement of Bioactive glass

Fig. 6

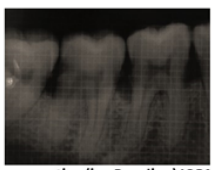
GTR Membrane placed with Sling suture

Closure of flap

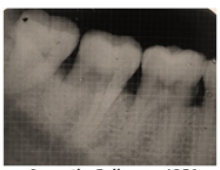
6 months Follow-up Clinical photo

Fig. 7

MTA

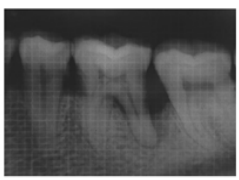


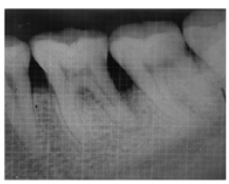
Pre-operative (i.e. Baseline) IOPA radiograph with 1 sq. mm grid



6 months Follow-up IOPA radiograph with 1 sq. mm grid

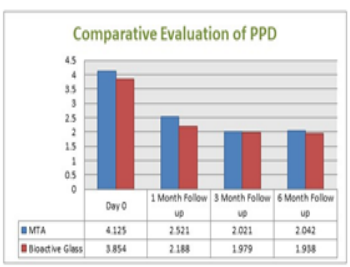
Bioactive Glass





Pre-operative (i.e. Baseline)and Post operative IOPA radiograph with 1 sq. mm grid

Chart1



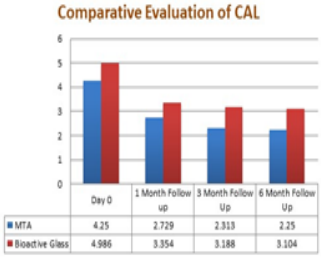


Chart 2

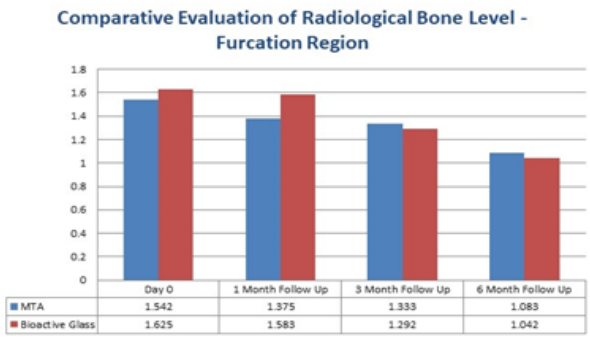
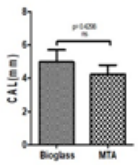


Chart 3

On the basis of CAL, there was no difference between two study groups (Bioglass and MTA)

	Bioglass	MTA
Number of values	12	12
Mean	4.986	4.250
Std. Deviation	2.533	1.904
Std. Error of Mean	0.7313	0.5496



On the basis of RM-F, there was no difference between two study groups (Bioglass and MTA)

	Bioglass	MTA
Number of values	12	12
Mean	1.625	1.542
Std. Deviation	0.8823	0.6201
Std. Error of Mean	0.2547	0.1790

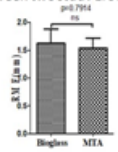
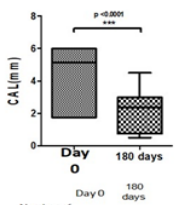


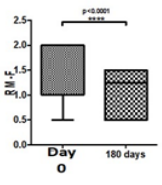
Chart 4

Effect of MTA on CAL



	Day 0	180 days
Number of values	12	12
Mean	4.250	2.250
Std. Deviation	1.904	1.406
Std. Error of Mean	0.549	0.4059

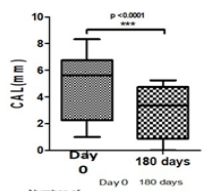
Effect of MTA on RM-F



	Day 0	180 days
Number of values	12	12
Mean	1.542	1.083
Std. Deviation	0.6201	0.4687
Std. Error of Mean	0.1790	0.1353

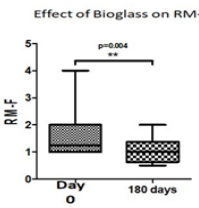
Chart 5

Effect of Bioglass on CAL



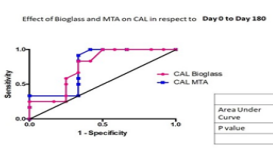
	Day 0	180 days
Number of values	12	12
Mean	4.986	3.104
Std. Deviation	2.533	2.013
Std. Error of Mean	0.7313	0.5810

Effect of Bioglass on RM-F



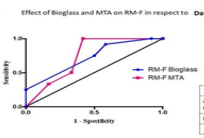
	Day 0	180 days
Number of values	12	12
Mean	1.625	1.042
Std. Deviation	0.882 3	0.4502
Std. Error of Mean	0.254 7	0.1300

Chart 6



Day 0 vs. Day 180

	Bioglass	MTA
Area Under Curve	0.7604	0.7743
P value	0.0304	0.023



Day 0 vs. Day 180

	Bioglass	MTA
Area Under Curve	0.7222	0.7431
P value	0.064	0.043

Data sheet

	Time Instance	Plaque Score	Gingival Score	PPD	CAL	Bone Level (Distance from CEJ to crest of alveolar bone or base of furcation defect)		
						Mesial	Furcation area	Distal
Follow up MTA	Day 0	1.708±0.098	1.875±0.131	4.125±0.815	4.250±1.904	1.458±0.62	1.542±0.62	1.500±0.603
	1 M	1.042±0.097	1.042±0.097	2.521±0.432	2.729±1.694	1.292±0.498	1.375±0.528	1.333±0.493
	3 M	1.208±0.258	1.146±0.198	2.021±0.926	2.313±1.386	1.250±0.44	1.333±0.481	1.292±0.437
	6 M	1.146±0.198	1.188±0.284	2.042±0.81	2.250±1.406	1.167±0.389	1.083±0.469	1.167±0.389
Follow up Bioactive Glass	Day 0	1.771±0.167	1.854±0.167	3.854±0.981	4.986±2.533	1.583±0.901	1.625±0.882	1.833±0.807
	1 M	1.125±0.226	1.125±0.226	2.188±0.4	3.354±1.964	1.542±0.909	1.583±0.919	1.771±0.801
	3 M	1.063±0.216	1.021±0.072	1.979±0.607	3.188±2.034	1.354±0.794	1.292±0.831	1.542±0.681
	6 M	1.042±0.097	1.042±0.097	1.938±0.622	3.104±2.013	1.042±0.45	1.042±0.45	1.208±0.335

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