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Efficacy of glycine powder air polishing in comparison with sodium bicarbonate air polishing and ultrasonic scaling – a double-blind clinico-histopathologic study

Abstract: *Background:* Subgingival biofilm removal using glycine powder air polishing (GPAP) has antecedently been shown to be safe. The hypothesis that GPAP is efficacious during periodontal maintenance therapy and results in less gingival erosion than sodium bicarbonate air polishing (SBAP) or ultrasonic scaling was assessed. *Methods:* Initial periodontal therapy was performed in each of the 22 chronic periodontitis patients having residual 5 mm probing depth in each quadrant and were randomly assigned to one of the following interventions: GPAP (test), SBAP (positive control), ultrasonic scaling (positive control) or no treatment. Clinical parameters were assessed, and gingival biopsies were taken immediately after instrumentation and sent for histological quantification. *Results:* Significant improvement in plaque and gingival index scores were noted in glycine powder air-polishing and ultrasonic group. GPAP resulted in minor erosion of the gingival epithelium (score 1 & 2), whereas positive control specimens displayed moderate to severe erosions (score 3 & 4). Difference between GPAP and positive control was significant. ($P < 0.05$). *Conclusion:* GPAP results in clinically significant improvement in plaque and gingival index scores and histologically causes less gingival erosion than SBAP or ultrasonic instrumentation, further supporting the safety of this debridement technique in periodontal maintenance therapy.

Key words: air-polishing; glycine powder; sodium bicarbonate; ultrasonic scaling

Introduction

Periodontal maintenance has been shown to play an important role in preventing loss of attachment [1]. Periodontal maintenance therapy (PMT) primarily involves supra- and subgingival biofilm removal. Traditionally, this is achieved using hand instruments and ultrasonic or sonic scalers. These procedures have been reported to be labour intensive and, when performed periodically, result in tooth substance loss over a period of time[2–4]. Hence, an air-polishing device (APD) with sodium bicarbonate powder as the abrasive agent was introduced for clinical use as an alternative to conventional techniques for plaque removal[5,6].

Sodium bicarbonate has been proven to be a proficient agent for supragingival plaque removal and less time consuming as compared to

hand instruments and rotating rubber cups[5,7,8]. However, the mean particle size and shape of sodium bicarbonate powders used in air-polishing devices make the powder more abrasive, resulting in tooth substance removal and at times causing soft tissue injury as well[9–11]. Thus, the omnipresent problem of related hard and soft tissue trauma, from sodium bicarbonate air-polishing (SBAP) application, compromises its routine use[8,12].

Recently, to facilitate the removal of plaque from root surfaces whilst minimizing trauma, a low abrasive air-polishing powder consisting of an amino-acid glycine salt was introduced[10]. The effectiveness of glycine powder air polishing (GPAP) in the reduction of cultivable subgingival microflora in periodontal pockets of 3–5 mm probing depth has been established[13,14]. To date, no reference in the literature comparing the efficacy of GPAP with SBAP and ultrasonic scaling has been found. The main purpose of this study was to assess the efficacy of GPAP in comparison with SBAP and ultrasonic scaling. The gingival effects from use of SBAP, GPAP and ultrasonic scaling were histologically evaluated.

Material and methods

Sample size calculation

If a difference in plaque index scores = 0.02 and a standard deviation of ±0.002 within each group is to be detected at a significant level $\alpha = 0.05$ with a power of $\gamma = 80\%$, the minimum number of patients required, as calculated by the software Primer Biostatistics version 5.0 (Baguio, Philippines), per group would be eight. To this value, we added the provision for dropouts and a final sample size per group was determined to be 10. The primary outcome variable selected was change in plaque index. Secondary variable was gingival index.

Patient recruitment

The study population was recruited from the outpatient section of the Department of Periodontology, Krishnadevaraya College of Dental Sciences and Hospital, Karnataka, India. Forty quadrants in 10 subjects with chronic periodontitis within the age range of 20–40 years, including both the sexes, were considered in the double-blind study. All enrolled subjects were informed about the study protocol and the possible complications and gave their written informed consent on a form, approved by the Ethical Committee of the Krishnadevaraya College of Dental Sciences, which is affiliated to the Rajiv Gandhi University of Health Sciences, Karnataka, India. The recruitment period was from December 2010 to September 2011.

Inclusion criteria

Systemically, healthy subjects presenting with chronic periodontitis having minimum of 6 teeth per quadrant and at least one site in each quadrant with probing depth ≥5 mm were included in the study.

Exclusion criteria

The exclusion criteria were as follows: (i) subjects with respiratory or any other conditions that limit swallowing or breathing and with any form of communicable infection that could contaminate the aerosols produced, (ii) subjects exhibiting lesions on gingiva, (iii) pregnant women and lactating mothers, (iv) patients who had received any topical or systemic antimicrobial treatment in the past 6 months, including the use of mouthwash, (v) patients who had periodontal treatment in the past 6 months and (vi) smokers.

Interventions

All subjects received an initial oral prophylaxis**.** They were recalled 3 weeks later for recording clinical baseline measurements of plaque index[15] and gingival index[16].

Three modes of instrumentation were randomly assigned to quadrants of each patient by straw method. Four uniform straws were numbered 1, 2, 3 and 4 that indicated no treatment, ultrasonic scaling, SBAP and GPAP, respectively. One single-blinded examiner drew the straws to allocate the specific treatment to a particular quadrant prior to intervention.

To prevent exposure of the tooth and gingiva adjacent to the mid-line, the area was covered with tin foil[17] during instrumentation.

Group 1 – No treatment: One quadrant in each patient remained untreated and served as the negative control.

Group 2 – Ultrasonic instrumentation: Debridement of the selected quadrant was carried out using ultrasonic instrument (EMS, Mini Piezon Ultrasonic Scaler) until no plaque was visible when checked with a probe.

Group 3 – SBAP: Teeth were debrided using sodium bicarbonate powder (EMS – Air Flow classic Powder) in a commercially available Air Polishing Device (Dentsply Prophy-Jet®, Dentsply, York, PA, USA) at a constant distance of 5 mm. Central powder–water jet was directed into the buccal or lingual aspect of the periodontal pocket at an angle of 60–70° to the root surface for 5 s per tooth[17].

Group 4 – GPAP: Teeth were debrided using glycine powder (EMS- Air Flow-Perio) in a commercially available Air Polishing Device (Dentsply Prophy-Jet®, Dentsply, York, PA, USA) at a constant distance of 5 mm. Central powder–water jet was directed into the buccal or lingual aspect of the periodontal pocket at an angle of 60–70° to the root surface for 5 s per tooth[17].

Subjects were recalled 3 weeks after the interventions were performed and the clinical parameters were reassessed. After subjecting the sample teeth to the predetermined interventions again, biopsies from one tooth each having PPD ≥5 mm were procured from each quadrant to investigate the soft tissue changes.

Biopsy procedure

Local anaesthesia was administered away from the biopsy area to prevent tissue damage from the injection. An internal bevel incision was made 2–3 mm from the crest of the gingival margin. Following this, a sulcular incision was made to reflect a mucoperiosteal flap. The marginal gingiva was then cautiously removed and immediately preserved in 4% phosphate-buffered formalin solution (pH = 7.4).

Histological investigation of the specimens

Preparation for light microscopy

After preserving in the formalin solution for 24 h, the biopsy samples were thoroughly washed in sterile water, followed by dehydration in an ascending series of alcohol. This procedure was succeeded by saturation in liquid paraffin for 24 h and finally casting in blocks. Serial cuts were prepared and stained with haematoxylin and eosin.

Qualitative and quantitative histological analysis

Ten representative slides were selected from each biopsy specimen and analysed by a blinded investigator. To assure correct blinding of the histologist, no prior information on the assignment of the specimens to the treatment groups was provided. Furthermore, all the specimens were assessed in random order. The investigator assigned one slide to every quadrant, and the histological parameter was scored using semiquantitative assessment of gingival damage (Table 1)[17].

Statistical analysis

Mean values and proportions relevant to clinical parameters were calculated for all groups. Descriptive analysis was carried out for this study. All data were subjected to test of normality, namely the Kolmogorov–Smirnov test. The clinical data achieved normality; hence, paired sample 't'-test was applied for comparison of parameters within each group. Significance was assessed at 5% level of significance. Post hoc Tukey's test was used to find the significant relationship between two or more groups with a '*P*'-value of <0.05. Fischer's exact test was used to find out the significant change in epithelial damage by different treatments having different outcomes. All data analyses were performed using a statistical software package (SPSS v. 15.0, IBM, Chicago IL, USA).

Results

A comparative split mouth quadrant clinical trial was conducted with ten chronic periodontitis subjects (40 sites), all of whom completed the study in accordance with the protocol (Fig. 1). There were six male and four female patients in the age range of 30–40 years. In order to standardize the baseline measurements, all participants were subjected to initial oral prophylaxis. The data to be evaluated were recorded at baseline and at the end of 3 weeks.

When comparison of means (± SD) was performed between baseline values and at the end of 3 weeks following intervention, improvements in the clinical parameters were observed in all the treatment groups, as depicted in the Tables 2 and 3. It was observed that except for the negative control group, all the groups showed an improvement in the plaque and gingival index scores. The most significant reduction in PI scores and GI scores was observed for Group II (ultrasonic $P < 0.001$ and 0.004 respectively). The comparison of PI and GI between all four groups was performed between the delta of measurements (0–3 weeks) showed significance, as shown in Tables 4 and 5, respectively.

In summary, the treatment modalities of ultrasonic scaling and GPAP, both, have rendered statistically significant results in the reduction in plaque and gingival inflammation.

Histological assessment

Biopsies of untreated gingiva were characterized by undamaged epithelium and connective tissue. Most of the negative control specimens showed a histological score of 1. Biopsies from sites treated with GPAP predominately displayed intact epithelial layers. The underlying lamina propria showed a normal structure. In majority of the specimens, the observed microscopic structure had a histological score of 1 (Table 5).

SBAP resulted in a discernible erosion of the oral gingival epithelium with focal exposure of underlying connective tissue. The lamina propria displayed strands of epithelial ridges extending into the connective tissue with signs of inflammation consisting of neutrophils and lymphocytes. Following SBAP, histological scores of 2 and 3 were mostly recorded, resulting in a significantly greater score than GPAP. ($P < 0.001$).

Considerable soft tissue damage was also found after ultrasonic instrumentation. In most specimens, there was disruption of the superficial epithelial layers with undamaged basal layers. The histological scores following ultrasonic instrumentation were 2 and 3. The representative specimens are displayed in Fig. 2.

Table 1. **Histological scoring for semiquantitative assessment of gingival damage**

Score	Microscopic detectable tissue change
1	No lesion: undamaged epithelium and connective tissue
2	Minor lesion: disruption of superficial epithelial layers, undamaged basal membrane
3	Medium lesion: superficial layers of the epithelium removed, basal membrane partially damaged
4	Severe lesion: epithelium and basal membrane completely removed, connective tissue exposed

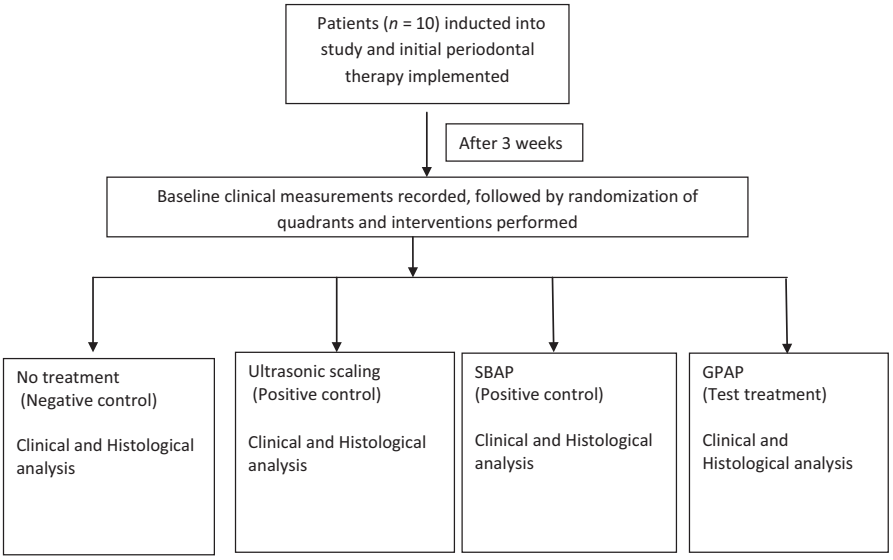

Fig. 1. Consort flow diagram

Table 2. **Comparison of (a) Plaque index scores and (b) Gingival index cores.**

	GPAP	SBAP	Ultrasonic scaling	Negative control
(a)				
Baseline	1.213 ± 0.084	1.140 ± 0.056	1.179 ± 0.087	1.186 ± 0.13
3 weeks	1.171 ± 0.061	1.125 ± 0.064	1.086 ± 0.081	1.235 ± 0.103
Δ	0.042	0.015	0.093	0.049
P-value	0.042*	0.213	<0.001*	0.029*
(b)				
Baseline	1.21 ± 0.09	1.24 ± 0.08	1.20 ± 0.06	1.24 ± 0.12
3 weeks	1.18 ± 0.07	1.22 ± 0.09	1.14 ± 0.06	1.27 ± 0.12
Δ	0.030	0.013	0.066	0.024
P-value	0.013*	0.152	0.004*	0.121

Δ difference; GPAP, glycine powder air polishing; SBAP, sodium bicarbonate air polishing.
**P*-value < 0.05 considered statistically significant.

Table 3. **Comparison of plaque index scores between different study groups**

Group comparison	Group Negative control-Group Ultrasonic	Group Negative control-Group SBAP	Group Negative control-Group GPAP	Group Ultrasonic - Group SBAP	Group Ultrasonic - Group GPAP	Group SBAP -Group GPAP
Baseline Δ	0.007	0.046	0.027	0.039	0.034	0.073
Baseline *P*-value	0.839	0.269	0.413	0.186	0.180	0.015*
3 weeks Δ	0.149	0.110	0.064	0.039	0.085	0.046
3 weeks *P*-value	0.001*	0.016*	0.034*	0.196	0.001*	0.055
P-value for difference of baseline and 3 weeks	<0.001*	0.026*	0.003*	<0.001*	0.015	0.065

**P*-value < 0.05 – statistically significant.
GPAP, glycine powder air polishing; SBAP, sodium bicarbonate air polishing.

In most samples, parakeratinized stratified squamous epithelium was seen with the underlying connective tissue showing moderate chronic inflammatory cells predominantly lymphocytes and plasma cells and dense collagen fibre in the form of bundles.

No untoward effects were noted throughout the complete study period, and healing was uneventful following biopsy.

Discussion

As there has been an ascending trend in patient awareness towards maintenance of a healthy periodontium, there is an increasing need for more comfortable and cost-effective means of periodontal debridement methods. Various innovations have been observed in the recent era with respect to new

Table 4. **Comparison Of Gingival Index Scores Between Different Study Groups**

Group comparison	Group Negative control-Group Ultrasonic	Group Negative control-Group SBAP	Group Negative control-Group GPAP	Group Ultrasonic - Group SBAP	Group Ultrasonic - Group GPAP	Group SBAP -Group GPAP
Baseline Δ	0.040	0.008	0.029	0.032	0.011	0.021
Baseline *P*-value	0.258	0.842	0.410	0.096	0.729	0.557
3 weeks Δ	0.130	0.045	0.083	0.085	0.047	0.038
3 weeks *P*-value	0.008*	0.326	0.026*	0.014*	0.193	0.325
P-value for difference of baseline and 3 weeks	0.008*	0.079*	0.010*	0.017*	0.082	0.200

*P-value < 0.05 – statistically significant.
GPAP, glycine powder air polishing; SBAP, sodium bicarbonate air polishing.

Table 5. **Comparative evaluation based on Histological score**

Histological score	Neg. Ctrl	GPAP	SBAP	Ultrasonic
No lesion: undamaged epithelium and connective tissue	9 (90.0%)	6 (60.0%)	0	0
Minor lesion: disruption of superficial epithelial layers, undamaged basal membrane	1 (10.0%)	4 (40.0%)	4 (40.0%)	8 (80.0%)
Medium lesion: superficial layers of the epithelium removed, basal membrane partially damaged	0	0	6 (60.0%)	2 (20.0%)
Severe lesion: epithelium and basal membrane completely removed, connective tissue exposed	0	0	0	0
Total	10 (100.0%)	10 (100.0%)	10 (100.0%)	10 (100.0%)

Inference – Medium lesion: superficial layers of the epithelium removed, basal membrane partially damaged is significantly associate SBAP group, with $P < 0.001$*.

instrumentation techniques, for example development of vector scaling systems, new designs of scaler tips, the use of plastic microbrushes and various modes of low abrasive air-polishing technique[18–21].

The use of air-polishing devices (APDs) allows a highly efficient and convenient method of removal of plaque and extrinsic staining[7,22]. Application of the abrasive jet consisting of sodium bicarbonate ($NaHCO_3$) powder, water and pressurized air to root surfaces, however, has resulted in severe tooth substance removal (up to 856 μm) within short periods of application[8–10]. This severely limits the use of this technique in patients with periodontitis, where denuded root surfaces are frequently found[23]. Previous studies have shown that the rate of root substance removal caused by an APD is highly influenced by instrumentation time, instrument powder and water setting as well as distance between the handpiece orifice and the surface to be treated[24,25]. It is, however, not possible to adjust these working parameters to apply the APD's jet to denuded root surfaces without causing severe damage and gingival erosion[24,26,27]. Although the gingival lesions heal uneventfully, application of SBAP on the gingiva should be avoided to prevent recession in thin scalloped biotype of gingiva[28].

Thus, to facilitate the removal of biofilm from root surfaces whilst minimizing trauma to hard and soft tissues, an amino-acid glycine salt was introduced[10]. The glycine powder has a mean particle size of less than 45 μm and a maximum particle size of 60 μm, in contrast to the sodium bicarbonate particle size, which is four times larger. Also, the sodium bicarbonate powder particles are said to be chiselled shaped, which may cause more abrasion to the soft and hard tissues as compared to glycine powder[28]. Glycine powder does not cause alterations in blood electrolytes unlike sodium bicarbonate[29]. Various studies have demonstrated the use of GPAP to be efficient and safe with respect to subgingival biofilm removal[10,13,14]. GPAP has been shown to reduce tooth substance loss by approximately 80% as compared to SBAP[10].

No available study was found in dental literature involving both the efficacy of GPAP and its effect on gingiva in comparison with SBAP and ultrasonic scaling, which is the intervention of choice during non-surgical periodontal therapy and periodontal maintenance therapy. Thus, this report stresses the subgingival removal of plaque and its effect on gingival inflammation by GPAP in comparison with ultrasonic scaling and SBAP and also the effect of each of the above interventions on gingiva.

To evaluate the effect of intervention on gingiva, biopsies of marginal gingiva were procured by placing 1st and 2nd incisions during periodontal flap surgery in sites with probing pocket depth of ≥5 mm, thereby showing an ethically justifiable indication for surgery and biopsy removal. The present study also has the added advantage of standardization as the application of GPAP was limited to 5 s per site and the slurry was applied in a constantly sweeping manner at a fixed distance of 5 mm from the tooth surface with the help of a special nozzle, as compared to previous studies which have

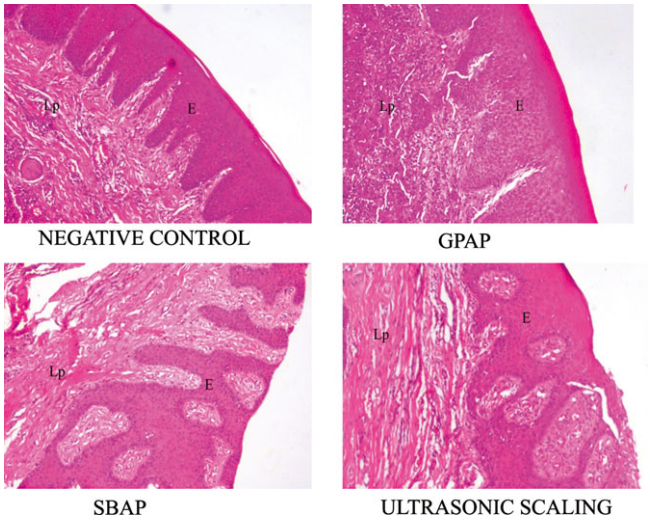

Fig. 2. Negative control: Light micrograph of the oral gingival epithelium without mechanical debridement. Tissue appearance is according to score 1. E, Epithelium; Lp, Lamina propria. Note: undamaged epithelium and connective tissue. Ultrasonic Scaling: Light micrograph of oral gingival epithelium directly after debridement using ultrasonic instrumentation. Tissue appearance is according to score 2. Note there is disruption of superficial epithelial layers, undamaged basal layers. E, Epithelium; Lp, Lamina propria membrane. SBAP: Light micrograph of oral gingival epithelium directly after treatment with sodium bicarbonate air polishing (SBAP). Tissue appearance is according to score 3. Note strands of epithelial ridges extending into the connective tissue due to stimulus of chronic inflammation. E, Epithelium; Lp, Lamina propria. GPAP: Light micrograph of oral gingival epithelium directly after debridement using glycine powder air polishing (GPAP). Tissue appearance is according to score 1 Note that the superficial parakeratinized layer is partly detached in the present specimen due to technical preparation. E, Epithelium; Lp, Lamina propria.

either been conducted on animals or have evaluated the effect of sodium bicarbonate and glycine powder on surface characteristics at different application distances (2–7 mm) and times (5, 10 and 30 s) with fixed nozzle position using atomic force microscopy[5,26,27,30].

The results of the present study indicate that GPAP is reasonably efficacious in the removal of plaque and also in the reduction of gingival index scores although in comparison, ultrasonic scaling produced better results with regard to plaque index scores. Previously, it was proven that GPAP is as effective as ultrasonic scalers and curettes in subgingival biofilm removal in periodontal pockets with probing depth up to 4 mm[31]. Wennstrom[32] conducted a study to ascertain the clinical and microbiological effects of subgingival air polishing and ultrasonic instrumentation during supportive periodontal therapy and concluded that there was an equitable reduction in the periodontal pathogens and probing pocket depths in both groups.

The gingival biopsies of the specimen in this study largely demonstrated no lesions in the GPAP samples with only minor epithelial erosions in four samples. In comparison, the ultrasonic group samples showed significant association with minor lesions and two samples were interpreted as having moderate lesions. This is in accordance with previous studies which evaluated the effect of glycine powder air polishing on gingiva[17]. This demonstrates that glycine powder is affable to the soft tissues as compared to ultrasonic scaling and indirectly suggests a more comfortable option for the patients especially when repeated treatment is planned in the form of PMT. The choice of working parameters including distance and spraying time and in particular the choice of abrasive powder plays a pivotal role in safety and effectiveness of the air-polishing process[10,11].

Subgingival air polishing has also been screened positively for the treatment of peri-implantitis cases. Sahm[33] carried out a comparative study to evaluate the efficacy of glycine powder air polishing versus mechanical debridement and chlorhexidine for the treatment of peri-implantitis and concluded, there was comparable clinical attachment gain in both groups, and the air-polishing group showed significantly less bleeding. Non-surgical periodontal therapy of severe peri-implantitis using air abrasion and Er:YAG laser also showed similar results with comparable and significant reductions in bleeding and suppuration[34].

Thus, in this age of evidence-based dentistry armed with the increasing confirmation of the efficacy and efficiency of subgingival air polishing using glycine powder, clinicians should consider incorporating this form of instrumentation for removal of soft deposits from the tooth surfaces. Further long-term studies may be required to assess the effects of repeated episodes of glycine powder air polishing on gingiva and hard tissue, as this procedure may be performed during periodontal maintenance therapy.

Conclusion

This study demonstrates that GPAP is a more efficient material for biofilm removal compared to SBAP and almost as effective as ultrasonic scaling during periodontal maintenance therapy. In addition, GPAP has a more docile effect on the soft tissues and causes less gingival erosion as compared to ultrasonic scaling.

Clinical relevance

Scientific rationale

The successful use of glycine powder air polishing for biofilm removal in comparison with hand instrumentation has been previously established. This study determines its effectiveness on reducing gingival inflammation and compares with ultrasonic scaling a more commonly used method of biofilm removal. It also evaluates its influence on gingiva.

Clinical findings

GPAP is as effective in plaque removal as ultrasonic scaling and has a milder abrasive effect on gingiva.

Practical implications

The study concludes that GPAP can effectively be used during periodontal maintenance therapy for biofilm removal and reduction in gingival inflammation.

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Sources of support/Conflict of interest

None.

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