Cellular and Molecular Biology
E-ISSN : 1165-158X / P-ISSN : 0145-5680
www.cellmolbiol.org

Preoperative CBCT Guided Bone Regeneration Combined with Concentrated Growth Factor Applied in the Implantation of Maxillary Teeth with Insufficient Bone Mass

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ARTICLE INFO

Original paper

Article history:
Received: August 12, 2022
Accepted: November 12, 2022
Published: December 31, 2022

Keywords:

Concentrated growth factor (CGF), bone regeneration, soft and hard tissue regeneration, guided bone regeneration (GBR), maxillary teeth region

ABSTRACT

It was to explore the application effect of cone beam computed tomography (CBCT) guided bone regeneration (GBR) combined with concentrated growth factor (CGF) in the implantation of maxillary teeth with insufficient bone mass. 78 patients with single maxillary anterior tooth loss and labial alveolar defects in Dazhong Stomatological Hospital were retrospectively analyzed and randomly divided into groups A and B. Both groups were treated with surgical methods of GBR at the same time of implantation. Group A: CGF fibrin fluid and Bio-Oss bone powder, covered with CGF membrane on the surface to guide bone regeneration. Group B: Bio-Oss bone powder was implanted and covered with Heal All collagen biofilm. The horizontal bone width, keratinized gingival width, bone plate thickness, implant margin results, and alveolar ridge width were analyzed at 3 and 6 months before and after the operation in both groups. 6 months after the operation, the difference in the indexes between the two groups was evident; and in group A, the indexes had an obvious difference in contrast with those before operation; the healing rate of soft tissue was 100% in group A and 80% in group B, which was significantly different ($P < 0.05$). Preoperative CBCT GBR combined with CGF can promote the bone formation content of guided regeneration of bone defects in the maxillary teeth region.

Doi: http://dx.doi.org/10.14715/cmb/2022.68.12.13

Introduction

With the continuous improvement of people's oral consciousness, dental implant restoration affects aesthetic observation, and implant restoration has become an important means of dentition defect repair (1). Tooth extraction can cause inevitable absorption of the labial bone plate, especially in the maxillary anterior region, the thickness of the residual pressure groove after anterior tooth loss is insufficient, which occurs mostly in clinical practice, and there will be significant bone resorption phenomenon 1 to 2 months after tooth extraction, causing labial bone wall defects and surface tissue collapse, affecting the aesthetics of the patient's face (2,3). More implant modalities used clinically for insufficient bone mass in the maxillary teeth region are delayed implants (4). Some scholars have also shown that physiological bone resorption on the labial or palatal side of the alveolar bone is generally about 3 to 4 mm after 6 months of tooth loss in the maxillary anterior region (5). Alveolar bone mass is generally difficult to meet requirements for the use of delayed implants in the upper anterior region (6). At present, guided bone regeneration (GBR) uses the implantation of artificial bone powder and covering the collagen membrane to induce bone regeneration and bone healing in the bone injury area and play a role in stabilizing bone augmentation and implants, which is popular in the application of bone augmentation, but the objective clinical evaluation is still lacking (7). Concentrated growth factor (CGF) is a repair biomaterial prepared from the patient's venous blood by special centrifugation, which has the unique properties of improving and enhancing tissue regeneration. CGF fibrin is an autologous biomaterial containing highly concentrated growth factors and collagen and has a strong ability to promote soft and hard tissue healing and regeneration (8,9).

Cone beam computed tomography (CBCT) is a noninvasive and trustworthy measurement tool characterized by short scanning time, low radiopharmaceutical, accurate measurement, and the ability to obtain clear images (10,11). CBCT was used before the operation, and CGF and GER were combined to evaluate the effect of soft and hard tissue regeneration in maxillary teeth with insufficient bone mass, so as to provide a reference for clinical oral treatment.

Materials and Methods

Study subjects

In this study, 78 patients with single maxillary anterior tooth loss and labial alveolar defect who visited the Department of Implant Medicine of Dazhong Stomatological Hospital from 2020.1 to 2022.1 were retrospectively analyzed, and the general data of the patients were analyzed. Among the 78 patients, there were 53 males and 25 females, aged 21 ~ 68 years old, with mean age of (35.4 ± 8.3 years) and mean body mass index of (22.42 ± 2.41) kg/m^2. All patients denied systemic diseases. 78 patients were randomly divided into group A and group B, 39 patients in each group. Both groups were treated with surgical methods of GBR at the same time of implantation. Group A: CGF fibrin fluid and Bio-Oss bone powder (Geistlich, Switzerland) covered with CGF membrane to guide bone

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regeneration. Group B: Covered with Heal All collagen biofilm (Yantai Zhenghai Biotechnology Co., Ltd.), Bio-Oss bone powder was implanted for GBR.

In group A, there were 12 males and 28 females, aged 21 ~ 60 years, with mean age of (48.6 ± 8.5 years) and mean body mass index of (22.23 ± 1.63) kg/m^2. Group B had 20 males and 19 females, and they were aged 23 ~ 68, with mean age of (47.6 ± 3.61) and mean body mass index of (23.37 ± 2.07) kg/m^2. There was no significant difference in the general data between the two groups ($P > 0.05$), and the baseline data were comparable. The vital signs of the two groups were stable, and there were no obvious contraindications for the examination. All patients who completely met the inclusion criteria signed the informed consent form before the operation, and the trial was approved by the Ethics Committee of Dazhong Stomatological Hospital.

Inclusion criteria: Clinical data were complete; Patients had good oral hygiene and could receive return visits as required; Absence of teeth in the maxillary premolar and molar region for more than 3 months; CBCT evaluation of single tooth upper anterior tooth loss showed horizontal bone mineral density ≤ 4.5 mm in the edentulous region, no obvious vertical bone resorption; No bone metabolism disease; Patients with alveolar ridge width greater than 5 mm suitable for simultaneous implantation and simultaneous bone grafting. Exclusion criteria: Patients with abnormal preoperative blood routine bleeding and coagulation time and liver and kidney function tests; Maxillary frontal sinus inflammation and other systemic diseases; Head and neck of patients who had chemoradiotherapy; Patients who can't tolerate implant surgery; Patients with mental stress before spectral CBCT examination.

Surgical methods

All patients underwent oral CBCT, blood routine, and coagulation function tests before surgery to complete periodontal system treatment such as supragingival scaling, subgingival scaling, and root planing, and the contents of full-mouth periodontal examination were recorded in detail. All patients received conventional anti-infective treatment with oral antibiotics half an hour before surgery, and CBCT was taken before surgery to assess the bone defect and available bone mass. The patients were in a semi-recumbent position and the dental chair position was adjusted to the appropriate angle. Routine disinfection of all patients' draping, mouth gargle for 3 minutes using 0.12% chlorhexidine gargle, the use of articaine for invasion anesthesia of the affected area, and then along the alveolar crest palatal incision, in the labial axis of the adjacent two teeth to make an intraluminal incision, in order to fully expose the bone surface of the edentulous area, flipping trapezoidal mucoperiosteal flap, granulation tissue was removed, and labial bone surface performed cortical bone treatment. In group A, a mixture of CGF fibrin fluid and Bio-Oss bone powder was placed in the labial bone defect area and covered with CGF membrane on the surface for GBR. During the operation, it was noticed that the CGF membrane needed to cross the crest of the grafted alveolar crest to the palatal side, and the edge of the collagen membrane should cover at least 2.0 ~ 3.0 mm of the defect area, the gingival soft tissue flap was repeatedly relaxed, and the tension-free close suture was performed using absorbable sutures.

Patients in group B were implanted with Bio-Oss bone powder covered with Heal All collagen biofilm for GBR. During the operation, the tension-free close suture was also performed, and cavity hygiene was paid attention to after the operation. 0.12% chlorhexidine gargle was used, antibiotics were administered for three days, and suture removal was performed 10 days after surgery.

CBCT examination

The edentulous region was scanned using CBCT (Sirona ORTHOPHOS XG 3G CBCT, Germany) before and after surgery as well as 6 months after bone grafting, and the scanned images were measured by CBCT software. The examination reading of all study subjects was performed by the same group of radiologists. The reading of image data and the measurement of experimental data were completed by three senior qualified attending physicians. The images were interpreted by the double-blind method. When the opinions were inconsistent, the third physician participated in the image analysis, finally reaching consistent diagnostic opinions. CBCT scanning parameter settings: exposure voltage 64K V, current 8 mA, exposure time 14.2 s, scanning time 10.8 s, scanning slice thickness 300 μm. The specific scanning steps were as follows: two adjacent teeth in the edentulous area were found on the arch screenshot to make a line, obtaining the planar graph, the number of layers intercepted was certain, and the position selected for the measurement of alveolar bone width on the labial or palatal side was the sagittal screenshot at the most concave maxillary alveolar bone. The vertical distance from the alveolar crest to the most concave part and the number of layers obtained were recorded.

Preparation of CGF

The venous blood of the patient was drawn into four 10 mL sterile vacuum tubes with vacuum negative pressure, without anticoagulant, and centrifuged in a centrifuge. Red blood cells and platelets clot in the lower layer, serum in the upper layer, and CGF fibril gel block containing growth factors and stem cells in the middle layer. The layering operation consisted of first decanting the serum, removing the bottom portion using round-tipped scissors, and then placing the remaining CGF layer on the film press pliers, which were pressed into the CGF membrane. 1 ~ portion or 2 portions of CGF was selected, scissor was used to cut it into particles of 1 ~ 2 mm. The sheared particles were thoroughly mixed with Bio-Oss bone powder (Geistlich, Switzerland), which was mixed to a paste in a blender (Sifradent, Italy), and the excess mixture above was sucked away, and the remaining was stored for later use.

Measurement indicators

After CBCT examination of alveolar bone in the two groups, the width of alveolar bone, labial bone plate thickness, osteogenic thickness, and the amount of bone resorption at the implant margin 2 mm below the top of the implant were measured and recorded in detail, and the data obtained were averaged three times.

The vertical distance from the midpoint of the proximal midway of the alveolar crest to the labial membrane-gingival junction in the edentulous region was measured using a periodontal probe 6 months before and after surgery.

Statistical methods

Statistical analysis was carried out by adopting SPSS 22.0 statistical software. Mean ± standard deviation ($\bar{x}\pm s$) presented measurement data, χ^2 test was applied to analyze enumeration data, and percentage (%) presented enumeration data. Statistically obvious differences were refined at $P < 0.05$. One-way analysis of variance was used to analyze the data before and after treatment within groups, and *t*-test was used to compare the data between groups.

Results

Patients' implant statistics

A total of 95 implants were used in 78 patients, as shown in Figure 1, Osstem, 36; Bego, 19; ITI, 15, 3i, 10; Icx, 8; Astra, 4; Hiossen, 3; preservation rate of implants was 97.4%.

Horizontal bone width CBCT measurements at different time periods

CBCT measurements of horizontal bone width were compared between the two groups before surgery, after surgery, 3 months after surgery, and 6 months after surgery, as shown in Figure 2, and there was no significant difference between the two groups before surgery ($P > 0.05$). The differences between the two groups at 3 and 6 months after operation and before treatment were significant ($P < 0.05$).

Comparison of keratinized gingival width at different time points

The difference between group A and group B at 6 months after surgery was obvious ($P < 0.05$), and that in group B between before surgery and 6 months after surgery was not obvious ($P > 0.05$). There was no obvious difference 3 months after the operation relative to before the operation ($P > 0.05$). There was no significant difference between the two groups 3 months after the operation ($P > 0.05$)(Figure 3).

Comparison of bone plate thickness at different time points between the two groups

The results of the comparison of the mean thickness of the bone plate of the alveolar bone on the labial or palatal side between the two groups are shown in Figure 4, and there was a significant difference in group A between 3 and 6 months after surgery and before surgery ($P < 0.05$). In group B, the difference was significant at 6 months after surgery compared with that before surgery ($P < 0.05$). From the end of the surgery, 6 months later, group A and group B had an evident difference ($P > 0.05$).

Implant margin outcome analysis

In group A, there was a difference between 6 months after the operation and before the operation as well as 3 months after the operation; and 6 months later, there was an obvious difference between the two groups ($P < 0.05$). Two groups had no obvious difference 3 months later; and in two groups, there was no obvious difference 3 months later compared with before the operation ($P > 0.05$) (Figure 5).

Comparison of alveolar ridge width between the two groups

Figure 6 illustrates obvious differences in the two groups at 3 and 6 months after surgery compared with before surgery ($P < 0.05$), and there were significant dif-

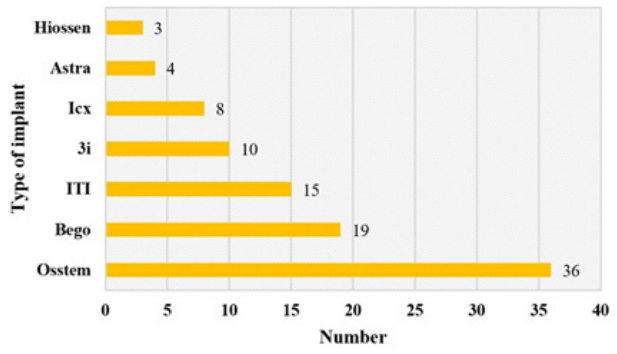

Figure 1. Patients' implant statistics.

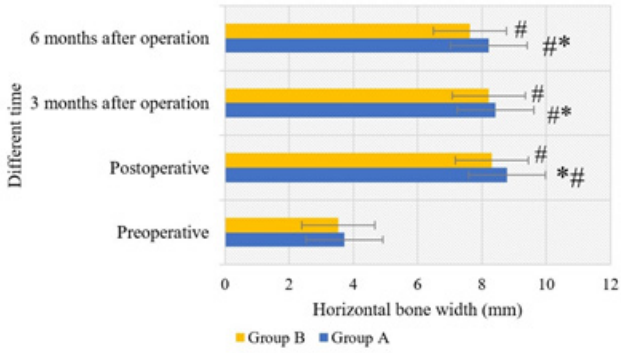

Figure 2. CBCT measurement results of horizontal bone width at different time points in the two groups. (Note: * means the evident difference between two groups, $P < 0.05$; # meansobvious difference between two groups at 3 and 6 months after the operation and before the operation, $P < 0.05$).

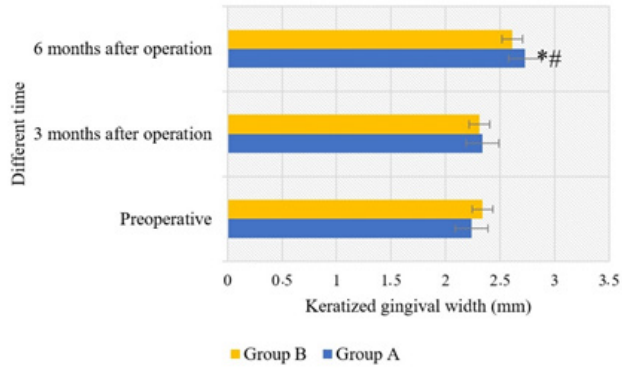

Figure 3. Comparison of keratinized gingival width between the two groups.

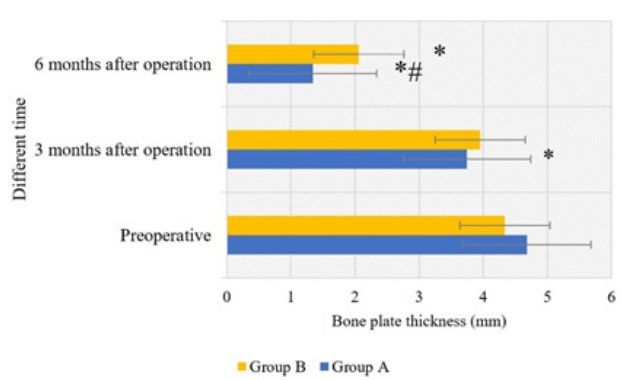

Figure 4. Comparison of bone plate thickness between the two groups.

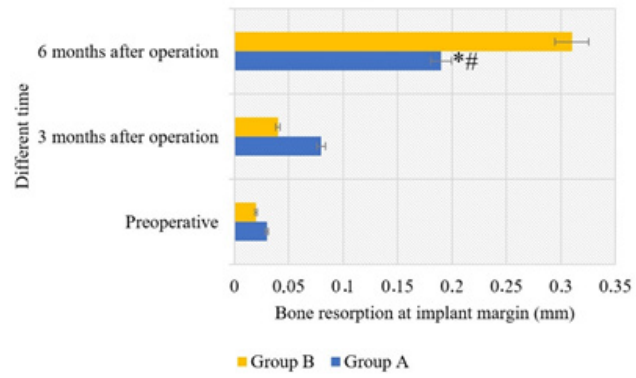

Figure 5. Analysis of implant margin results in the two groups.

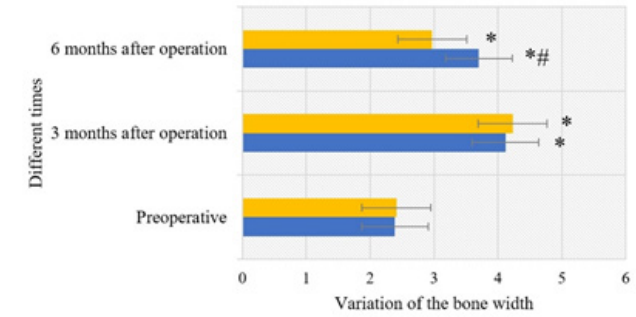

Figure 6. Comparison of alveolar ridge width between the two groups.

ferences between group A and group B at 6 months after surgery ($P < 0.05$). There was no significant difference between group A and group B 3 months after the operation ($P > 0.05$).

Comparison of healing rate between the two groups

Figure 7 illustrates the soft tissue healing rate was 100% (group A) and 80% (group B) ($P < 0.05$).

Image presentation

Figure 8 shows the dental implant procedure and CBCT images. Figure 8A shows CBCT guide plate positioning; Figure 8B illustrates a plane diameter measurement, red indicates the measurement range, and Figure 8C is a postoperative CBCT image, showing that CBCT images can be used in the evaluation of the effect of implant surgery for insufficient bone mass in the maxillary teeth region.

Discussion

There are many methods and equipment in the diagnosis and treatment of alveolar bone, such as manual caliper, histomorphometric analysis, and periodontal probe, but their accuracy is not very high. Skeletons, cartilage, and tendons have limited ability to repair themselves, and adult tissues tend to have insufficient regenerative capacity following trauma or disease. When organs or tissues are compromised by irreparable injuries, they may be replaced by artificial devices or donor organs, and insufficient alveolar bone volume impacts bone regeneration in dental implants (12,13). CBCT has many advantages, such as lower price, less metal artifacts, less radiation, and the ability to obtain high-resolution images, and can be used clinically to measure multiple peri-implant bone dimensions at different times (14). Porto et al. (2020) (15) utilized the lowest mean CBCT bone thickness. In the mandible, buccal bones around premolars and premolars as well as lingual mandibular molars bone thickness are thinner, and all these anatomical features may make sinus tracts more likely in this specific maxillary and mandibular alveolar bone areas.

López-Jarana et al. (2018) (16) anatomically described bone morphology in the maxillary and mandibular teeth regions using CBCT scanning methods, which may aid in planning for post-extraction implants, and found that in more than 80% of evaluated sites, the high incidence of buccal wall thickness less than 2 mm suggests the need for additional regenerative procedures; and that customized abutments may be required in some locations to address the angle of screw-retained crowns. Zambrano-De et al. (2020) (17) used CBCT to compare the buccal alveolar bone thickness and buccal and lingual inclination angles in mesially angulated mandibular impacted third molar (MITM). They found that the superior and middle buccal alveolar bone thickness was greater in mesially angulated B-lingual inclined MITM than buccal inclined MITM. These studies illustrate that CBCT has good measurement results in applied studies in the maxillary teeth region. CBCT GBR was used to measure and analyze the maxillary teeth region of patients. The soft tissue healing rate was 100% in group A and 80% in group B. There was a significant difference between the two groups ($P < 0.05$), which indicated that CBCT GBR could clearly present the alveolar lesion area with high accuracy so that the patients had good treatment results.

Patients in group A were analyzed for insufficient bone mass in the maxillary region using GBR combined with CGF, and patients in group B were implanted with Bio-Oss bone powder with a surface covered by Heal All collagen biofilm. After simultaneous implantation and simultaneous bone grafting with the GBR technique, there were significant differences in horizontal bone width, keratinized gingival width comparison, bone plate thickness comparison, implant margin result analysis, and alveolar ridge width comparison between the two groups 6 months after operation ($P < 0.05$), and the osteogenic effect was good. Whether implants undergo marginal bone

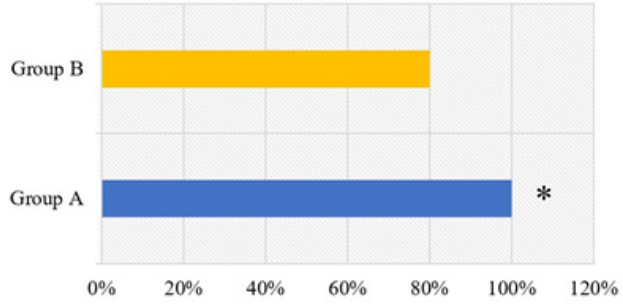

Figure 7. Comparison of healing rate between the two groups.

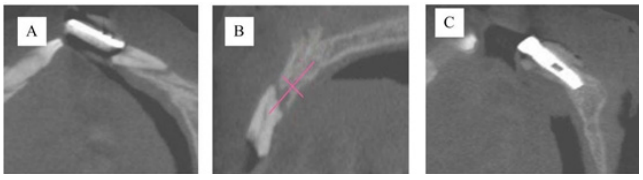

Figure 8. Different surgical procedures and CBCT images. (A: CBCT guide plate positioning; B: plane diameter measurement, red indicates the measurement range; C: postoperative CBCT image).

loss is also an important criterion for evaluating the success of the individual constitution (18). RasouliGhahroudi et al. (2010) (19) and Donovan et al. (2010) (20) stated that early peri-implant bone resorption occurred mainly in the labial and buccal sites of implants, bone resorption occurred mainly in the non-loading phase, and bone resorption was most abundant in the first year after dental implant placement. Group A was significantly better than group B for bone resorption. In group A, CGF was used, which was mainly used to promote soft and hard tissue healing and regeneration in periodontal implants, and the GBR ability of labial bone defects in the maxillary tooth region was significantly better in group A than in group B, which also indicated that the good osteoinduction and osteoconductivity of CGF were fully reflected. CGF is a platelet concentrate, which is a promising scaffold for the treatment of dentin-pulp complex diseases and is autogenous, convenient, easy to use, and biodegradable. CGF has many growth factors, and the main mechanism of action is that various high concentrations of growth factors together with fibrinogen constitute a fibroreticular scaffold. CGF has obtained popularity in the medical and dental fields in repairing bone defects and promoting soft tissue healing. Li et al. (2021) (21) elaborated on the role and potential application of CGF in the regeneration of the dentin-pulp complex, many in vitro studies have shown that CGF can promote the proliferation and migration of dental stem cells. Chen et al. (2021) (22) stated that CGF has been most evaluated in implant-related therapies and maxillofacial bone regeneration, and most of these articles showed good results. CGF is the latest generation of concentrated platelets, and Chen and Jiang (2020) (23) elaborated that CGF has a good application in facial rejuvenation, cartilage transplantation, facial bone defects, facial peripheral nerve injury and trauma. The active component of CGF is able to stimulate the migration and differentiation of osteocytes in bone graft materials (24). Oliveira et al. (2021) (25) pointed out tissue engineering and regenerative medicine address to some extent the shortcomings associated with bone disease treatment and consequent tissue regeneration. Tissue engineering facilitates structures that can mimic extracellular matrix and enable the use of signaling molecules to guide natural bone repair to promote osteoinduction and angiogenesis necessary for new bone tissue formation. Patients with CGF were able to present new bone around the implants 6 months after surgery. Synthetic bone powder combined with CGF is osteoconductive and osteoinductive. Simultaneous implant placement using the GBR technique in the maxillary anterior region is stable, safe, and reliable, and is a good augmentation procedure.

Conclusion

CGF in patients has good biocompatibility and can promote GBR of labial bone defects in the maxillary anterior region, and the use of CBCT GBR combined with CGF before surgery can promote the bone formation content of guided regeneration of bone defects in the maxillary tooth region and has certain quantitative diagnostic advantages. The limitation is that the follow-up duration of the patients is short, and the bone gain of the maxillary anterior region after 1 year can be analyzed at a later stage. The observation time should also be increased and the sample size should be expanded in clinical practice to provide a basis for the clinical diagnosis and treatment of implants with insufficient bone mass in the maxillary region.

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