

Axiograph and Panoramic Radiographic Imaging Technique, an Alternative to Conventional Technique to Record Condylar Guidance

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ABSTRACT

Introduction: The documentation of the maxillomandibular relationship and the recording values of condylar guidance is the most critical, yet essential step in fabrication of complete denture prosthesis and it also helps in diagnosing, treatment planning, and fabrication of the balanced complete denture prosthesis that aids in enhancing the aesthetics, and maintenance of the stomatognathic system. Various techniques are available to record the condylar guidance; These are axiographic technique and panoramic radiograph followed by programming the semi adjustable articulators.

Aim: The aim of the present study was to evaluate and compare the condylar guidance using the conventional technique the gothic arch tracing with that of axiographic technique and the panoramic radiographs.

Materials and Methods: The observational study with the clinical set up was carried out over a period between October 2018-March 2019. Twenty completely edentulous patients were selected for the study. The comparative evaluation of Axiographic tracing technique, Panoramic radiographic technique and the Extraoral gothic arch tracing technique was conducted. The horizontal condylar guidance values obtained with these techniques were assessed. The data obtained was statistically analysed using Karl Pearson correlation test to determine the correlation between the values obtained from all the three techniques on the right side and the left side of the subjects. Paired t-test and Bonferroni Post-Hoc test were

used to compare the Extraoral gothic arch tracing values and Orthopantomogram values and axiographic tracing values on right side and left side of the subjects.

Results: A statistically significant correlation was observed between the extraoral Gothic arch tracing technique and the Panoramic radiographic technique on right ($r=0.047$, p -value 0.04) and left sides ($r=0.55$, p -value 0.01) of the subjects. The axiographic tracing showed lower values when compared with gothic arch tracing technique and the Panoramic radiographic technique (95%CI of difference was -0.49 lower). Significant differences were obtained on comparison between all three techniques on right (p -value <0.001) and left sides (p -value 0.008). On pairwise comparison of right sides between Extraoral gothic arch Tracing and Axiographic tracing (p -value <0.001) and between axiographic tracing and Orthopantomographic tracing (p -value <0.001) were significant, while pairwise comparison on left side between Orthopantomogram and Axiographic tracings (p -value 0.01) were significant.

Conclusion: The panoramic radiographic images can be used as an alternative method to that of conventional gothic arch tracing technique to obtain the condylar guidance values. The values obtained using axiographic tracings method was comparatively lower. Thus, the values obtained from axiographic technique should be used with caution or the values needs to be compared to gold standard techniques to further analyse the accuracy of the values that can be used as a valuable aid in setting the condylar guidance in semi-adjustable articulators.

Keywords: Axiographic tracing, Extraoral gothic arch tracing, Horizontal condylar guidance, Interocclusal record, Panoramic technique

INTRODUCTION

The temporomandibular joint and the condylar inclinations is the utmost important factor in prosthodontic rehabilitation, and the maintenance of the stomatognathic system. Precise recording of the maxillomandibular relationship and establishing the condylar guidance will aid in improved efficiency of the complete denture prosthesis. Fabrication of the balanced complete denture prostheses is often carried out indirectly in the absence of the patient on a semi-adjustable articulator, hence to re-establish the lost maxillomandibular relationship in a completely edentulous patient is the most difficult task. However, a historical review in dentistry reveals that there are numerous techniques, philosophies, and materials that can be manipulated and used to record the maxillomandibular relationship, in centric and all the eccentric movements (left lateral, right lateral and protrusive movement) of the maxillary and mandibular jaws. The conventional and the gold standard technique for recording the condylar guidance is Gothic arch tracing technique, the only disadvantage being time consuming and manipulation errors during the transfer to the articulator [1,2]. Thus, there is a need to exercise the newer and easy techniques to record the condylar guidance that

is less time consuming technique. Recent development in a semi-adjustable articulator has introduced the use of interocclusal bite records and axiographic techniques to record static, as well as the dynamic movement of the mandible, and also record the condylar guidance while programming the articulator. Axiographic technique is less cumbersome as compared to the gothic arch tracing. The reason for determining the condylar guidance differences on right and left side was that the right and left eminences seldom have exactly the same contours, slants and declivities [3-6]. The present study was conducted to evaluate and compare the axiographic technique and the Panoramic radiographic technique that can be used as an alternative method to record condylar guidance values over the conventional Gothic arch tracing technique.

MATERIALS AND METHODS

This observational study under clinical set up was conducted over a period of 6 months between Oct 2018-March 2019. Based on the observations made in the pilot study, the following sample size of 20 edentulous subjects was calculated using the G*Power 3.1 software.

Inclusion criteria: Patients with completely edentulous maxillary and mandibular arches and with good neuromuscular function, visiting Department of Prosthodontics, AB Shetty Memorial Institute of Dental Science, Deralakatte, Mangalore were selected to participate in the study after obtaining the informed consent.

Exclusion criteria: The patients with restricted and deviated mouth opening, and patients with the history of disorders of temporomandibular joint and muscles of mastication were excluded from the study.

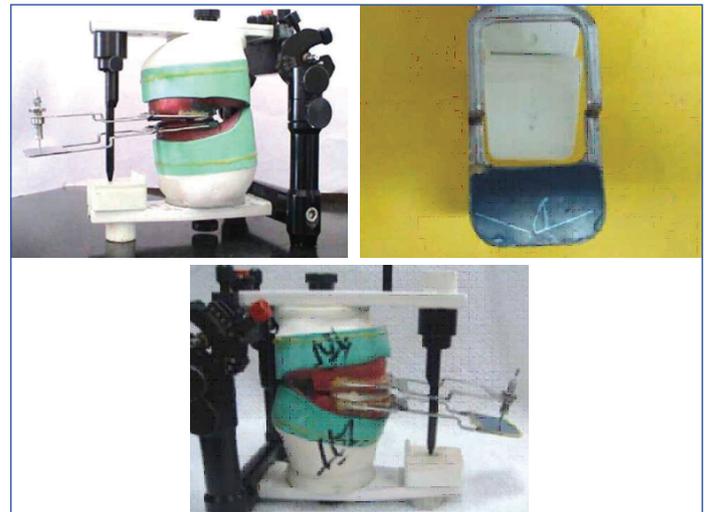
The ethical clearance was obtained from the ethical committee- Nitte (Deemed to be university) Mangalore (approval no. NU/CEC/2016-2017/0080).

The subjects fulfilling the inclusion criteria were selected for the study and the treatment was planned to fabricate the balanced complete denture prosthesis. The treatment was initiated with making of primary impression using the conventional techniques following which border molding and secondary impressions were made. The master casts were prepared using dental stone, the denture bases and occlusal rims were fabricated on the master casts. The occlusal rims were adjusted in the patient's mouth to register the maxillomandibular relationship; the tentative centric relation was registered at the conventionally established vertical dimension. The face bow transfer was done following which the maxillary cast was mounted on the semi adjustable articulator (Artex®, GIRRBACH DENTAL). Later the mandibular cast was mounted in the articulator using the tentatively registered jaw relation; the mandibular occlusal rims were reduced by 3 mm as a space for the attachment of the Extraoral gothic arch tracers and for the interocclusal recording medium.

Extraoral Tracing with Interocclusal Bite Recording Technique

The extraoral tracing assembly (Hight extraoral tracer assembly) was attached to the mounted bases on the articulator [Table/Fig-1]. Patient was asked to do required movements. When the patient was proficient in executing all the movements, the tracing plate was dried and thin layer of soot was applied evenly so that no resistance was offered to the movement of the stylus that was attached to the maxillary occlusal rims, following which the patient was asked to move the mandible in centric relation and all the eccentric relations, the clearly visible tracing were made by the stylus on the tracing plate. The definitive arrow point tracing with sharp apex was obtained, the pointer of the stylus was adjusted to be at the point of the apex of the arrow point tracing. Quick setting dental plaster was injected between the occlusal rims and the plaster was allowed to set. The tracing plate was removed and conformed for sharp apex indicating centric relation [Table/Fig-2]. The record bases were placed back into the articulator; the mark made by the pin was confirmed to coincide with the apex of the tracing following which the protrusive interocclusal record was obtained. A hole was made 6 mm from centric hole in secured tracing plate with blank radiographic film, and the bases were replaced in patients mouth and the lower jaw was guided in a protrusive movement till the stylus enters the notch made on the radiographic film. The protrusive record was obtained using quick setting impression plaster; tracing assembly with recording bases was transferred to the articulator. The condylar posts were set at 0 degrees, the incisal pin was raised of the incisal table and the locknuts were loosened. The recording bases were returned to the articulator (Artex®, GIRRBACH DENTAL) and maxillary rim was aligned so that it coincides with the imprints on mandibular rim. The locknuts were moved back and forth one side at a time until the maxillary rim was firmly and securely seated against the lower index, and the stylus pointer coincided with the hole made i.e., 6 mm from the centric relation point. Protrusive relation record was adjusted three times and results were averaged before the horizontal condylar guidance was set and locknut was tightened

with hand pressure [Table/Fig-3]. In all the cases articulator was programmed by single operator.



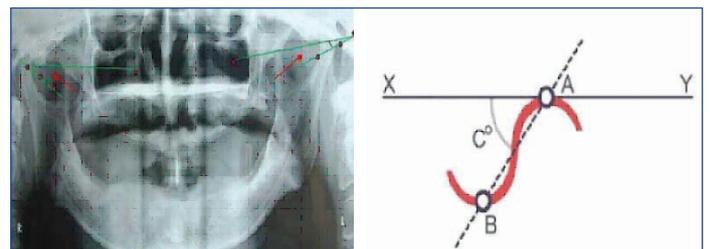
[Table/Fig-1]: Record bases with tracing devices attached.

[Table/Fig-2]: Extraoral Gothic arch tracing.

[Table/Fig-3]: Interocclusal record is positioned in the articulator. (Images clockwise)

Panoramic Radiography

A panoramic radiograph was taken using orthopantomogram (PM2002CCPROLINE). All radiographs were made by the same operator and with the same radiographic unit; the image was acquired at 74 kvp, and 10 mA. Tracings were made of the images of each radiograph on tracing paper. Images were traced for Frankfort horizontal plane which passes through the lowest point in the margin of the orbit and highest point in the margin of auditory meatus. Outline for most superior point on the articular eminence and inferior point on the articular tubercle just adjacent to zygomatic arch were traced [Table/Fig-4]. A line was drawn connecting most superior and inferior points of curvature representing the mean curvature line [Table/Fig-5]. The angle was measured between mean curvature line and the reference line, each measurement was repeated twice, twenty panoramic radiographic images were traced independently before making interpretation, and the data were subjected to the statistical analysis [Table/Fig-5].



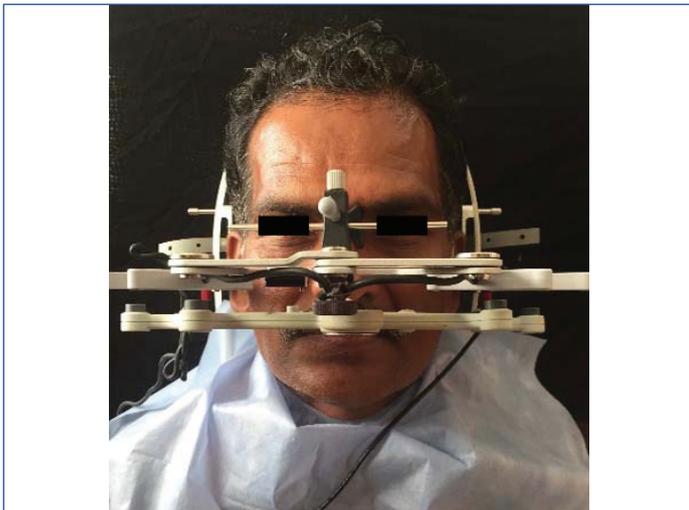
[Table/Fig-4]: Panoramic radiograph showing landmark used.

[Table/Fig-5]: Tracing of line AB joining height of superior curvature A and inferior curvature B, representing inclination of articular eminence is angle made by intersection of mean curvature line and horizontal reference line. (Images from left to right)

Axiographic Technique

The patients were asked to visit the Temporomandibular joints (TMJ) Clinic where the computerised recording of mandibular movement was made by using axiographic jaw tracking device, the axio-quick recorder, ultrasonic Axiograph, was used to record mandibular movement. The combination of Axioquick® with a contactless ultrasonic recording device allows the 3D acquisition of all mandibular movements [Table/Fig-6]. The patients were seated in an upright position following which the jaw tracking device was attached to the waxed up complete denture, the device was attached to the monitor that works on software version 1.0, SAM 3 to record the jaw movement. The recording of the jaw movements was received while patients was asked to open the jaw in rotational movement and translational movement of the jaw, later the patient was asked

to make left lateral and right lateral movement and protrusive movement. The values obtained from the axiograph were utilised to program the semi-adjustable articulator [Table/Fig-6,7]. These values obtained from axiographic tracing were compared with the values obtained from Gothic arch tracers, and the orthopantomographic values. Following which the obtained data was statistical analysed.



[Table/Fig-6]: Axiograph tracing.

SAM AXIOUICK RECORDER Examination Report					
Right			Left		
Protar Articulator Settings					
HCI (deg)	35.3	HCI (deg)	31.5		
Retrus (mm)	0.6	Retrus (mm)	0.9		
ISS (mm)	0.0	ISS (mm)	0.0		
BEN (deg)	4.0	BEN (deg)	4.0		
Shift (deg)	Track is too short.		Shift (deg)	-20.0	
Artes Articulator Settings					
HCI (deg)	27.8	HCI (deg)	24.0		
Retrus (mm)	0.6	Retrus (mm)	0.9		
ISS (mm)	0.0	ISS (mm)	0.0		
BEN (deg)	7.4	BEN (deg)	5.3		

Incisal Table (only valid tooth guided)

Horizontal

[Table/Fig-7]: Condylar guidance angle on axiograph.
 HCI: Horizontal condylar inclination; Retrus: Retrusion; ISS: Immediate side shift; BEN: Biomechanical evaluation

STATISTICAL ANALYSIS

The correlation between the Axiographic tracing technique, Gothic arch tracing technique and the Panoramic radiographic technique

Techniques studied	Sides studied	N	Mean (°)	Std. Deviation (°)	Mean Difference	95% Confidence interval of the difference		t	df	p-value
						Lower	Upper			
Extraoral gothic arch tracing	Right	20	33.00	7.50	5.25	0.48	10.02	2.30	19	0.03*
	Left	20	27.75	9.52						
Orthopantomogram	Right	20	36.50	7.72	4.15	-0.08	8.38	2.05	19	0.05
	Left	20	32.35	9.45						
Axiographic tracing	Right	20	25.65	2.03	0.10	-0.49	0.69	0.36	19	0.73
	Left	20	25.55	2.06						

[Table/Fig-10]: Comparison between right and left side Extraoral gothic arch tracing, orthopantomogram, and axiographic tracing values. Paired t-test; *p<0.05 Statistically Significant

was assessed by using Karl Pearson correlation test. Paired t-test was used to compare right and left side. The comparison between the Axiographic tracing technique, Gothic arch tracing technique and the Panoramic radiographic technique on left and right sides was assessed by using Anova test and Bonferroni Post-Hoc Test. A p-value less than 0.05 were considered as statistically significant.

RESULTS

Data collected was tabulated and statistically analysed. The correlation between the right and left side of the extraoral Gothic arch tracing, orthopantomogram and axiographic tracing values. A statistically significant positive correlation was found for horizontal condylar guidance between both the sides of panoramic radiograph technique and axiographic technique (r=0.46, p=0.04, r=0.81, p=0.001) [Table/Fig-8].

Correlation between extraoral Gothic arch tracing, orthopantomogram, and the axiographic tracing values of right and left side of the subjects [Table/Fig-9]. A positive correlation was found between the right Extraoral gothic arch tracing and right and left side of OPG. Also, a positive correlation was observed between the left Extraoral gothic arch tracing and left OPG.

The comparison between right and left side of the Extraoral gothic arch tracing, Orthopantomogram, and Axiographic tracing values [Table/Fig-10].

Techniques studied		Left		
		Extraoral gothic arch tracing	Orthopantomogram	Axiographic tracing
Right	Extraoral gothic arch tracing	r	0.302	
		p-value	0.20	
	Orthopantomogram	r		0.46
		p-value		0.04*
	Axiographic tracing	r		0.81
		p-value		<0.001*

[Table/Fig-8]: Correlation between right and left side Extraoral gothic arch tracing, orthopantomogram and axiographic tracing values. Pearson's Correlation Test; *p<0.05 Statistically Significant

Techniques studied		Orthopantomogram		Axiographic tracing		
		Right	Left	Right	Left	
Extraoral gothic arch tracing	Right	r	0.47	0.57	0.003	-0.03
		p-value	0.04*	0.008*	0.99	0.91
	Left	r	0.37	0.55	0.27	0.33
		p-value	0.10	0.01*	0.25	0.15
Orthopantomogram	Right	r			0.19	0.07
		p-value			0.43	0.78
	Left	r			-0.10	-0.11
		p-value			0.68	0.64

[Table/Fig-9]: Correlation between extra oral gothic arch tracing, orthopantomogram, and axiographic tracing values of right and left side of the subjects. Pearson's Correlation Test; *p<0.05 Statistically Significant; p>0.05 Non Significant, NS

The average horizontal condylar guidance angles and the standard deviations between the right side and the left side of the Extraoral Gothic arch tracing was $33\pm 7.50^\circ$ on the right side and on the left side was $27.92\pm 9.52^\circ$, respectively. The average horizontal condylar guidance angles and the standard deviations between the right side and the left side of the orthopantomography was $36.5\pm 7.72^\circ$ and $32.35\pm 9.45^\circ$, respectively. The average horizontal condylar guidance angles and the standard deviations between the right side and the left side of the axiographic tracing were $25.65\pm 2.03^\circ$ and $25.55\pm 2.06^\circ$, respectively. Statistically significant differences were observed between right and left sides in Extraoral gothic arch Tracing. The other two techniques showed nonsignificant differences between both the sides.

[Table/Fig-11a] shows the comparison between Extraoral gothic arch tracing, orthopantomogram, and axiographic tracing values on the right and left sides. Significant differences were obtained between the techniques on right and left sides.

Statistically nonsignificant values were obtained with pairwise comparison on right side where the mean difference between extraoral tracing and orthopantomography was -3.50 [Table/Fig-11b]. On pairwise comparison on the left side where the mean difference between extraoral tracing and orthopantomography, and between the extraoral tracing and the axiographic tracing was -4.60 and 2.20, respectively. Statistically nonsignificant values were obtained between the extraoral tracing and orthopantomography; and the extraoral tracing and axiographic tracing on left side [Table/Fig-11b].

Sides studied	Techniques studied	N	Mean (°)	SD	Repeated measures ANOVA	
					F	p-value
Right	Extraoral gothic arch tracing	20	33.00	7.50	20.47	<0.001*
	Orthopantomogram	20	36.50	7.72		
	Axiographic tracing	20	25.65	2.03		
Left	Extraoral gothic arch tracing	20	27.75	9.52	5.55	0.008*
	Orthopantomogram	20	32.35	9.45		
	Axiographic tracing	20	25.55	2.06		

[Table/Fig-11a]: Comparison between Extraoral gothic arch tracing, Orthopantomogram, and Axiographic tracing values on the right and left sides.
*p<0.05 Statistically Significant; p>0.05 Non Significant, NS

Sides studied	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-value	95% Confidence interval for difference	
						Lower bound	Upper bound
Right	Extraoral gothic arch tracing	Orthopantomogram	-3.50	1.76	0.18	-8.11	1.11
		Axiographic tracing	7.35	1.74	0.001*	2.79	11.91
	Orthopantomogram	Axiographic tracing	10.85	1.70	<0.001*	6.39	15.31
Left	Extraoral gothic arch tracing	Orthopantomogram	-4.60	2.01	0.10	-9.87	0.67
		Axiographic tracing	2.20	2.02	0.87	-3.11	7.51
	Orthopantomogram	Axiographic tracing	6.80	2.21	0.02*	0.99	12.61

[Table/Fig-11b]: Pairwise comparison between extraoral Gothic arch tracing, Orthopantomogram, and Axiographic tracing values according to right and left side.
Bonferroni Post-Hoc Test; *p<0.05 Statistically Significant; p>0.05 Non Significant, NS

DISCUSSION

The successful treatment of complete denture prosthesis is based on the long-term preservation of alveolar bone along with functional balance of Stomatognathic system [3,4]. Posselt U and Nevstadt P concluded in their study that individual registration of condylar path inclination should be used instead of mean value adjustment [5]. Payne JA stressed the importance of determining and obtaining the values of the condylar guidance rather than relying on average values. Author also reviewed the literature of various studies of recording protrusive condylar angle and found it ranged from 22-65°, with the average of 38° [7]. Arstad T compared the articulator setting from various techniques like Gysi, Stansbery, Hanau, and it was concluded that none of the methods using situational interocclusal records can be considered reliable when a thermoplastic material is

used and that functional engraving or grinding in method can register the movements of the mandible and those of the bases on the soft tissues [8]. The prominent outline of the articular eminence can be viewed on the panoramic radiograph and can be utilised to program the articulator. However, the tracings obtained from axiograph may also be used to program the semi-adjustable articulator [9]. All the values were evaluated, compared and statistically analysed. Based on the results obtained, the Gothic arch tracing method is the ideal technique of recording the mandibular movement in centric and eccentric motion, which helps to obtain accurate condylar guidance values, with the help of traced arrowhead and plaster records of centric and protrusive movements. The low error index was obtained between the two radiographs; the angular values are acceptable since the variation found were less than 5 degrees. Variations of horizontal condylar guidance greater than 5 degrees were noted after repeated registrations in patients with TMJ disturbances as well as in patients treated with complete denture. This could be explained by the fact that horizontal condylar angulations vary greatly on either sides and from one individual to another and the variations can be determined with Gothic arch tracing techniques [10]. There are some inherent inaccuracies and limitations in this application regarding panoramic distortion, head and reference plane orientation, and difficulty in distinguishing the articular eminence outline from the zygomatic arch. Parallax errors may arise, if the beam becomes directed from either above or below due to positioning errors and the positions of these two lines relative to each other may vary. The articular eminence inclination in the radiographic image was traced from the most superior to the most inferior points of curvature, representing mean inclination of the curve. This may be different from the guiding inclination with approximately 4mm to 6mm of protrusion, which is the clinically significant range of protrusion and condylar guidance. Considering the inaccuracies of the interocclusal record technique within the range of errors of up to 30 degrees, the radiographic articular eminence image may have clinical relevance. Based on the literature survey, the average condyle guide settings values were considered to be accurate by the clinicians to program the articulator [11]. However, the mean setting value of condylar guidance on a semi adjustable articulator is 30 to 40 degrees is used. When the

true incline is flat (0-10 degrees) may be used or if the true incline is steep (70- 80 degrees) may be used, the discrepancy while obtaining the condylar guidance values will have an influence on the outcome of prosthetic restorations, as these will be used to programme the semi-adjustable articulator following which the complete denture prosthesis will be fabricated, the inaccurate condylar guidance settings may lead to failure of the prosthesis, the control over the protrusive and lateral eccentric guidance and posterior disocclusion or the attainment of a completely balanced articulation may be adversely affected [12]. Based on the observations made on overall results the panoramic radiographic images can be used to program the semi adjustable articulator and to check the reliability of using the Axiographic tracing techniques to programme the semi adjustable articulator further studies have to be carried out.

The present study demonstrated three techniques Gothic arch tracing technique, Panoramic radiographic technique, and axiographic technique. The Panoramic radiographic technique had considerably reliable readings. Thus, it can be used as an adjunct to the traditional Gothic arch tracing in programming articulator and thus providing effective treatment.

Limitation(s)

The limitation of the study was the small sample size. The distortion of the panoramic radiographs may result in blurring of the morphology of the anatomical landmark. Radiation exposure and positioning of the patients head may alter the readings. The Axiographic tracing technique may cause distortion of the mandibular arch if highly resorbed. Also, the tracings can be done only in the patients with good interarch space.

CONCLUSION(S)

The practicability of the three techniques and the consistency of the results considered that the radiographic method can be used as an alternative to the gold standard Gothic arch tracing technique to record condylar guidance values that seems to be most suitable for clinical use which is less time consuming and easy to manipulate. However, the axiographic technique also can be used as an alternative technique to panoramic radiographic imaging technique and the Gothic arch tracing technique, as all these three techniques were used in individual patients and values obtained were compared, further the articulator was programmed and complete denture prosthesis were fabricated and inserted in patients mouth, the follow-up report showed no clinical issues while

the complete denture prosthesis was in function. Further studies with large sample size are recommended in future.

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