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Radiation in Dental Practice: Awareness, Protection and Recommendations

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ABSTRACT

Radiation is the transmission of energy through space and matter. There are several forms of radiation, including ionizing and nonionizing. X-rays are the ionizing radiation used extensively in medical and dental practice. Even though they provide useful information and aid in diagnosis, they also have the potential to cause harmful effects.

In dentistry, it is mainly used for diagnostic purposes and in a dental set-up usually the practicing dentist exposes, processes and interprets the radiograph. Even though such exposure is less, it is critical to reduce the exposure to the dental personnel and patients in order to prevent the harmful effects of radiation. Several radiation protection measures have been advocated to ameliorate these effects.

A survey conducted in the Bengaluru among practicing dentists revealed that radiation protection awareness was very low and the necessary measures taken to reduce the exposure were not adequate. The aim of the article is to review important parameters that must be taken into consideration in the clinical set-up to reduce radiation exposure to patients and dental personnel.

Keywords: Radiation, Dosimetry, Radiation protection, Exposure.

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INTRODUCTION

Radiation has become a part of modern living, reaching every segment of our society. All individuals are exposed to ionizing radiation, both from natural and man-made radiation sources.[1] Radiation is the energy that comes from a source and travels through some material or through space. Light, heat and sound are types of radiation. Radiation may be ionizing or nonionizing. Ionizing radiation is radiation with sufficient energy to remove an electron from an atom or molecule. This ionization produces free radicals, i.e. atoms or molecules containing unpaired electrons, which tend to be especially chemically reactive. X-rays are ionizing rays which are used extensively in diagnostic procedures.

Apart from using X-rays and gamma-rays as diagnostic tools in medicine its usage extends to nuclear reactors to luggage X-ray inspections. Dental practice has its own way of radiation exposure. The practicing dentist differs from medical colleagues as he exposes, processes and interprets the radiograph. Though the exposure is minimal it is very important to reduce the radiation to avoid the accumulated dose to the dentist in their lifetime.

Radiation Hazards

The discoveries of X-rays and radioactivity had its own advantage and disadvantages. Scientists learnt that radiation is not only a source of energy and medicine, but it could also be a potential threat to human health, if not handled properly. The early pioneers in radiation research died from radiation-induced illnesses due to excessive exposure. Initially, the dangers and risks posed by X-rays and radioactivity were poorly understood. In March 1896, Edison reported eye irritation associated with the use of X-rays, and cautioned against their continuing use. He abandoned his own studies devoted toward an X-ray energized fluorescent light. By the end of 1896, numerous reports on X-ray dermatitis and serious injuries had been published in the scientific literature. By 1896, however, 'X-ray burns' were being reported in the medical literature, and by 1910, it was understood that radioactive materials could cause such 'burns'. By the 1920s, sufficient direct evidence (from radium dial painters, medical radiologists, and miners) and indirect evidence (from biomedical and genetic experiments with animals) had been accumulated to persuade the scientific community that an official body should be established to make recommendations concerning human protection against exposure to X-rays and radium.[2-4]

The International Commission of Radiation Protection (ICRP) is the international regulatory body, formed in 1928 to lay down norms for protection against radiation and recommend dose limits for radiation workers and general public. The Indian regulatory board for protection against radiation is AERB, Atomic Energy Regulatory Board which was constituted on November 15, 1983. The mission of the boards is to ensure that the use of ionizing radiation and nuclear energy in India does not cause undue risk to health and surroundings.[5]

BACKGROUND

Sources of Radiation

Sources of radiation can be categorized as natural and artificial. Natural radiation from external and internal sources yields the largest contribution to radiation exposure. External sources, cosmic and terrestrial, contribute 35% of world's natural radiation.[6] Sources of internal radiation are radionuclides that are taken up by inhalation and ingestion. Radon (inhalation) is the largest single contributor to natural radiation (52%). Contribution from the artificial (man-made) radiation has increased and originates mainly from medical field, consumer and industrial products and other minor sources. Currently, the medical uses of radiation constitute more than 99.9% of radiation exposure to the world's population from man-made sources.[7] CT scanning accounts for the 42 % of collective effective dose arising from medical diagnostic radiology.[2] Everyday around the world 10 millions diagnostic radiology procedures and 1 lakh diagnostic nuclear medicine procedures are being conducted.[7]

Exposure and Dose Reduction

Critical factor in discussing the effects of radiation is not the amount of radiation at a point in air (exposure) but rather than the amount of energy absorbed by a tissue at specific point (dose). So in a clinical practice we should give more importance to the dose reduction. Dose reduction can be achieved mainly in 3-steps decision-making, optmizing radiologic procedures and patient protection (Flow Chart 1).

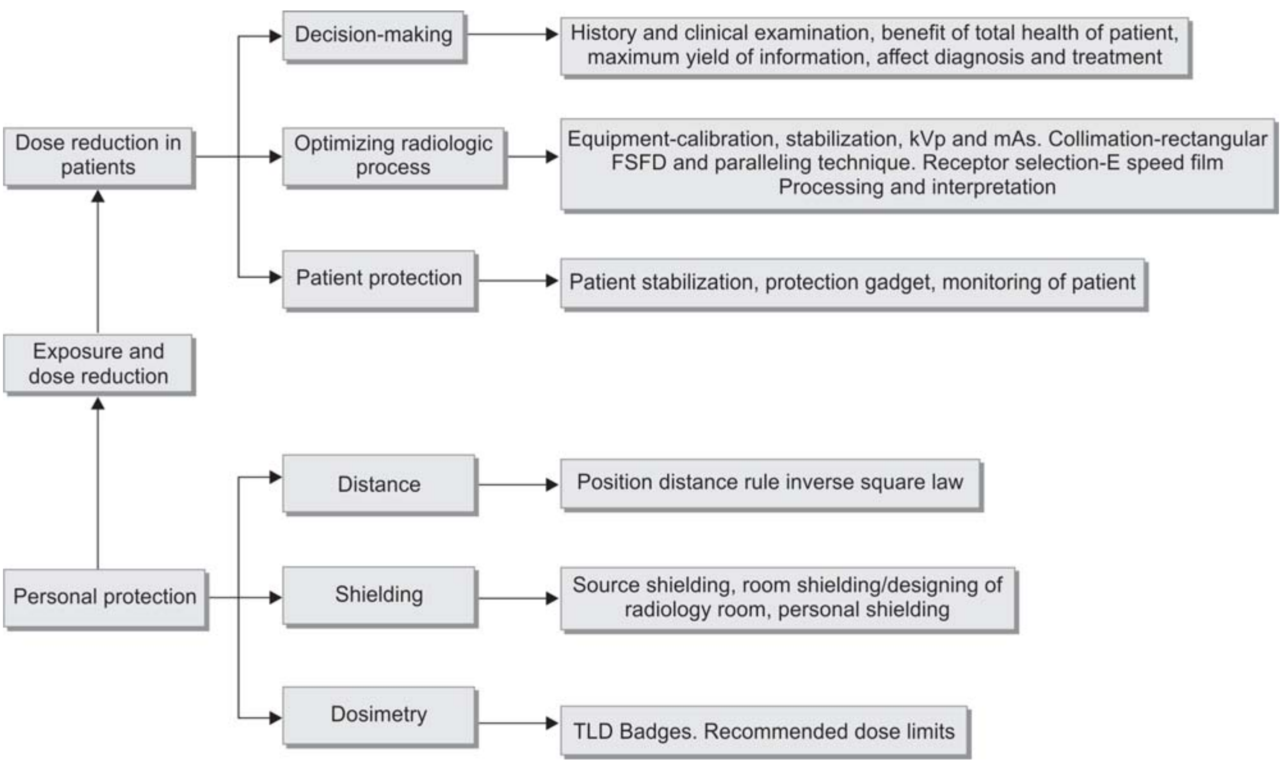
Decision-making

Radiographic examination shall be performed only when indicated by patients history and physical examination and when radiological investigation can affect the diagnosis and treatment. Decision to use diagnostic radiography rest on professional judgment, its necessity for the benefit of total health of the patient. If this decision has been made, it is then becomes the duty to produce a maximum yield of information per unit of X-ray exposure.[1]

Optimizing Radiologic Procedures

In dental practice more importance should be given to optimizing radiologic procedures, as it is the best way to minimize patient and operator exposure. Exposure

Flow Chart 1: Methods of exposure and dose reduction in patients and dental personnel



modification can be achieved by taking action at 3 levels of radiologic process—at source, at the exposure pathway and modifying characteristics or location of exposed individuals. Every measure must be taken to prevent retaking of image.[1,8]

Source (equipment): Drifting of dental X-ray tube should be avoided during positioning for exposure. This movement can cause blurred image or cone-cutting. The use of closed end and pointed cones are contraindicated, because of increased scattered radiation. Ionizing chamber or other X-ray detecting devices (e.g. unfors multi-o-meter) can monitor output dose of a machine when placed in front of position indicating device (PID). A well-calibrated dental X-ray machine will have an output of 0.7 to 1 R/sec.[8] This calibration must be done in every 3 years.[8] Calibration of Planmeca Promax OPG (orthopanthomograph) machine using Unfors Mult-O-Meter shows no scattered radiation even at 5 meter distance. Calibration shown in Figure 1, Tables 1 and 2.

Fig. 1: Calibrating exposure dose from IOPAR and OPG machine using Unfors Mult-O-Meter

kVp and mAs should be adjusted according to the contrast and density of image needed. High contrast image with low kVp are used for visualizing large differences in the density within a object, e.g. caries and soft tissue calcification. Increased kVp, allows visualization of small differences in density, e.g. bone level in periodontitis. High kVp reduces the effective dose delivered per exposure. Image density is controlled by quantity of X-rays produced, which in turn controlled by mA and second.

Collimation: using of rectangular open ended PID (3.5 × 4.4 cm) reduces the skin exposure by 60% than that of round (7 cm) PID.[13] Focal spot film distance (FSFD)–when X-ray machine is operated above 50 kVp, source skin distance must be greater than 7 inches.[9] Studies shows that 16 inch FSFD decreases 38% of thyroid dose, at 90 kVp and 45% decrease in 70 kVp, compared to 8 inch FSFD.[10] This is because at the greater distance X-ray beam is less divergent and there will be 32% reduction in exposed tissue volume.[11] The use of longer FSFD also results in a smaller apparent focal spot size and thereby increases the resolution of radiograph.[12]

Technique: Paralleling technique gives more accurate image and lowers the exposure dose to thyroid gland and lens of eye. In bisecting technique X-ray beam has steep vertical angulations that may put the thyroid gland and lens in the path primary as well as secondary radiation.[8] Increasing FSFD and rectangular collimation may result in 70 to 80% decrease in exposure.[14]

Receptor selection: It is advised to use maximum sensitive film (speed) consistent with image quality. E (Ektaspeed) speed film is almost twice as fast as D speed films.[15] In 1994 improved E speed film (Ektaspeed plus) was introduced, which was found to be faster, less sensitive to

Table 1: Depicting the calibration of Planmeca promax OPG machine, Finland, using Unfors Mult-O-Meter distance, kVp, times are constant

No.	Distance (cm)	Input			Output		Dosage	
		kVp	mA	Time	kVp	Time	µGY	µGY/S
1	52	70	2	1	72	1.01	198	195.6
2	52	70	4	1	72.8	1.01	407	402.2
3	52	70	8	1	72.2	1.01	821	810
4	52	70	12	1	72.4	1.01	1.01 mG	1.24 mG/s
5	52	70	16	1	72	1.01	1.01 mG	1.62 mG/s

Table 2: Depicting the calibration of Planmeca Promax OPG machine, Finland, using Unfors Mult-O-Meter distance, mA, times are constant

No.	Distance (cm)	Input			Output		Dosage	
		kVp	mA	time	kVp	time	µGY	µGY/S
1	52	60	8	1	61.7	1.01	596.8	589
2	52	65	8	1	66.6	1.01	707	697
3	52	70	8	1	72.2	1.01	821	810
4	52	75	8	1	78.7	1.01	939	926
5	52	80	8	1	85	1.01	1.06 mG	1.048 mG/s

processing and less grainy than E speed film and have high contrast similar to D speed films.[16] Dose reduction of 60% compared with E speed film can be achieved by using digital intraoral radiography. When compared with film, resolution was significantly lower in RVG whereas exposure reduction was to approximately half of Ektaspeed Plus.[24] Similarly digital panoramic imaging has been reported to result in dose reduction of 70%.[1]

Processing and interpretation of the image: Thirty-percent of all retakes are because of the incorrect film density, directly related to processing variability.[17] Radiographic images should be viewed under proper condition with illuminated viewer to attain maximum available information. Quality radiographs reduces retaking and unnecessary second exposure.[1,8]

Patient's Protection

Stabilization of patient head before the exposure decrease blurring and cone-cutting of the image. All radiation exposure must be based on the principle ALARA (as low as reasonably achievable). Mean exposure at skin entrance for single periapical film is 217 mR and gonad dose will be 1/10,000 of total beam exposure (0.02 mR).[18] Lead aprons reduce 98% of scattered radiation and attenuate dose to a 0.04 μR.[19] Interesting is this quantity is 60 times less than the dose equivalent resulting from one airline flight.[1] Thyroid collar attenuate 92% of scattered radiation.[20] So it should be made mandatory to use thyroid collar and lead aprons before any exposure. Film holders avoid unnecessary exposure to patient's fingers. Patients exposure history must be maintained and updated after every exposure.[8]

The greatest risk to the fetus for chromosomal abnormalities and subsequent mental retardation is between 8 and 15 weeks of pregnancy. So the examination involving radiation to the fetus should be avoided during this period. In second and third trimester, radiologic examination is advised, if it can alter the diagnosis and treatment planning and it is mandatory to use lead aprons and other dose reduction procedures.[1]

Protection of Personnel

From the occupational perspective there are two sources of radiation, X-ray tube is the true primary source of radiation but in practice only very few situations in which personnel will directly exposed to the primary beam. This leaves the secondary source, which is the patient. Interaction of the primary beam with the part of the patient's body being imaged produces scattered radiation, which emits from the patient in all directions. So any procedure that reduces the exposure to patient also reduces the possibility of operator exposure. In most cases, the main determinant for occupational exposure is proximity of personnel to the patient when exposures are being made. Increasing the distance from the source and shielding from radiation sources have proven to be greater importance in protecting operator and public from potential risk of radiation.[1]

Distance: Exposure decrease inversely as the square of the distance (inverse square law). According to position distance rule operator should stand at least 6 feet from patient at an angle of 90 to 135° to the central ray of X-ray beam. This rule take the advantage of inverse square law to reduce X-ray intensity but also consider that in this position most scattered radiation is absorbed by patient's head. In mobile radiography (dental), the operator should remain at least 2 meter away from the patient, X-ray tube and primary beam during exposure.[21]

Shielding: Shielding implies that certain material (concrete, lead) will attenuate radiation when they are placed between source and operator. Shielding include X-ray tube shielding, room shielding, and personnel shielding. AERB[22] recommends maximum allowable leakage from tube housing not greater than 1mGy/hr/100 cm^2. Room and personnel shielding—according to AERB guidelines: (i) Room housing an X-ray unit for dental/OPG should not be less than 12 m^2; (ii) Walls of X-ray room on which primary beam falls is not less than 35 cm thick brick and walls of scattered X-ray falls is not less than 23 cm thick brick; (iii) 1.5 mm lead in front of the doors and windows of X-ray room; (iv) unshielding openings in an X-ray room should located above a height of 2 m from finished level outside the X-ray room; (v) rooms should provided with direct viewing and oral communication facilities between operator and the patient; (vi) protective barrier between the operator and should have a minimum lead equivalence of 1.5 mm, protective apron and gloves should have minimum lead equivalence of 0.25 mm. One millimeter of lead thickness attenuates 99% beam at 75 kVp.[22]

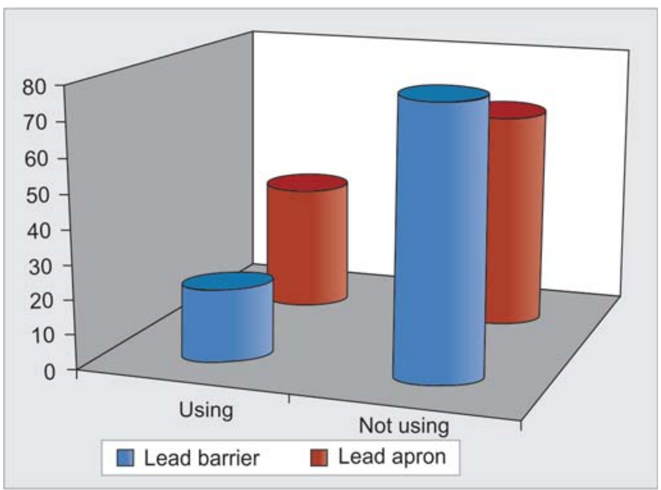
Radiation Detection and Dosimetry

Instruments used to detect and measure radiation are called radiation dosimeters. The purpose of radiation monitoring is to ensure that the dose limits were not exceeded and protection measures are doing well. There are several methods of detecting radiation, based on physical and chemical effects produced by radiation exposure. These methods are ionization, photographic effect, luminescence and scintillation. Thermoluminescent monitoring badges (TLD) are commonly used in India. Thermoluminescene is the property of certain materials to emit light when they are stimulated by heat. The amount of light emitted is proportional to the radiation dose. Materials such as lithium fluoride, lithium borate, calcium fluoride and calcium sulfate have been used to make TLDs. During radiography the dosimeter is worn at one of 2 regions—on the trunk of the body at the level of the waist on the anterior side of the individual or on the upper chest region at the level of the collar area on the anterior surface of the individual.[22] Badge should send for the dose measurement in every 3 months. Future technology is under development that utilizes compact personal electronic monitoring devices that wirelessly connect to a base station. So all the staff involved in a complex imaging procedure can monitor their doses in real time and use this information to modify their practice. For a real time continuous measurement of gamma radiation dose, a wireless sensing method was developed based on the polymerization of acrylamide.[26]

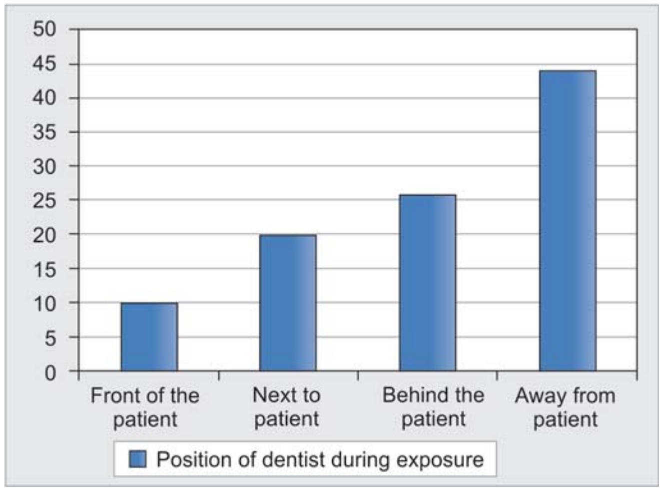
A questionnaire survey has been conducted in 100 dental clinics in and around Bengaluru. The aim of the survey was to understand the level of knowledge of radiation protection among dentist population in and around Bengaluru. Clinics with X-ray facilities were selected for the survey. Among 100 dentists 47% of dentists were using short cone and 60% of the dentist's position were near the patient while exposing. Survey shows only 20% were using lead barrier and more than 60% dentist were disposing the radiation waste into gutter. The result shows that radiation protection among dentist is unsatisfactory in Bengaluru. Hence, awareness of radiation protection and safety measures should be followed in order to have hazard free profession. The Graphs 1 and 2 show the inference of the survey.

Recommended Dose Limits

Dose limit apply only in planned exposure situations but not to medical exposures of patients. Within a category of exposure, occupational or public, dose limit apply to the sum of the exposures from sources related to practices that are already justified. Recommended dose limit is given in Table 3.[22,23,25]



Graph 1: Usage of lead barrier and lead apron by dentist



Graph 2: The position of the dentist during exposure

Table 3: Recommended dose limit[22,23,25]

Dose quantity	*Occupational dose limit*
Effective dose	20 mSv per year averaged over 5 consecutive years (100 mSv in 5 years)
Equivalent dose in	
Lens of the eye	150 mSv in a year
Skin	500 mSv in a year/cm^2
Hands and feet	500 mSv in a year

CONCLUSION

Though exposure to radiation in dentistry is minimal, it is very important to follow the guidelines to minimize the radiation exposure. Following the AERB guidelines while constructing the radiological unit and monitoring the individual exposure and quality of instruments is very useful in radiation protection. Knowledge on the type of radiologic equipment and the calibration of the machine during purchase and later should be made mandatory. The simple steps during the establishment of the radiological units and compliance for the AERB guidelines will help the individual for dose reduction in dental practice.

REFERENCES

1. White, Pharoah. Oral radiology principles and interpretation, (4th ed) Mosby 2000:42-61.
2. Radiation and risk—a hard look at data, a brief history of radiation. Los Alamos Science. 1995 Nov-23 available at http://www.fas.org/sgp/othergov/doe/lanl/00326631.pdf.
3. Kathren RK. Pathway to paradigm, the linear non threshold dose response model in historical context. Health Phys 1995; 70(5):621-35.
4. Edison TA. NOTE, Nature 1987;53:421.
5. Narayanan P. Radiological safety in health care: Guidelines, practice and outcome. Medical Physics Chronicle 2010 Jan;2(1).

6. Ramachandra TV, Eappen KP, Nair RN. Environmental assessment division, atomic research center. Background exposure levels. Indian scenario. Available at http://www.dae.gov.in/ni/nifeb05/PDF/03Indian_scenario.pdf
7. United Nations Scientific Committee on the effects of Atomic Radiation (UNSCEAR) 2008 report to general assembly. Available at http://www.unscear.org/unscear/en/publications/2008_1.html.
8. Frommer, Savage S. Radiology for the dental professional (8th ed) Elsevier Mosby 2005:78-104.
9. Code of federal regulations 21, sub chapter j: Radiological part 1000, Washington DC. 1994. Available at http://www.glenbrooktech.com/radiation-safety.php
10. Gibb SJ, et al patient risk from intraoral dental radiograph, J Dento Maxillo Facial Radiology 1988;17:25.
11. Frederikser NL. The radiograph in the diagnosis of periodontal disease, a quality assurance programme, technology assessment. Forum in Dental Radiology 1982;82:107.
12. Platin, et al. Effects of focal spot size on caries diagnosis with D and E speed images. Oral Surg Oral Med Oral Pathol Oral Radiol Endo 1996;81:235.
13. White SC. Assessment of radiation risks from dental radiography J Dento Maxillo Facial Radiology 1992;21:118.
14. Lederberg RA. et al. Effect of geometry of the intraoral PID on effective dose. Oral Surg Oral Med Oral Pathol Oral Radiol Endo 1997;84:101.
15. Richards, et al. Reduction in dental X-ray exposures during past 60 years. J Am Dent Assoc 1981;103:713.
16. Ludlow, et al. Densitometric comparison of ultraspeed. ektaspeed and ektaspeed plus intraoral films for 2 processing conditions. Oral Surg Oral Med Oral Pathol Oral Radiol Endo 1995;79: 105.
17. Goldman, et al. Automatic processing and quality assurance programme: Impact on radiology department. Radiology 1977; 125:591.
18. Richards AG. Roentgen ray doses in dental radiography. J Am Dent Assoc 1958;56:351.
19. Bean LR, Devore WD. The effect of protective aprons in dental Roentgenography. Oral Surg 1969;28:505.
20. Sikorski PA, Taylor KW. The effectiveness of thyroid shield in dental radiography. Oral Surg 1989;68:776.
21. Seeram, Travis EC. Radiation protection Philadelphia. New York, Lippincott 1997.
22. AERB safety code (Code No. AERB/SE/MED-2) Mumbai 2001 (1-20).
23. International commission in radiological protection. The 2007 Recommendation of the International Commission on Radiological Protection, ICRP Publication 103. Ann ICRP 2007;37:1-332.
24. John Ludlow, et al. Image-receptor performance: A comparison of Trophy RVG UI sensor and kodak ektaspeed plus film. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;91: 109-19.
25. Le Heron J, Padovani R, Smith I. Renate Czarwinski Radiation protection of medical staff. European J Radiol 2010;76:20-23.
26. Nan DU, et al. Developing a wireless sensing method for the measurement of gamma radiation dose based on the polymerization of acrylamide. Radiation Measurements 2012; 47(5):371-74.

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