Clinical Radiography in the Orthodontic Practice

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One practitioner's approach to minimizing patient exposure in diagnostic x-ray procedures in an individual orthodontic practice.

KEY WORDS: RADIATION, RADIOGRAPHY, RARE EARTH, X-RAY

As a practicing clinical orthodontist, the Author is frequently asked, "Are these x-rays necessary and safe?" "What about all of these articles on the dangers to my child in later life?"

Radiographs are necessary components of an adequate diagnosis, so I constantly strive to maximize the diagnostic information while minimizing the risk to my patients. This paper presents one clinician's approach to orthodontic radiography. The techniques described here have proven to be valuable in my own practice, but I do not necessarily advocate all of them for universal application. The following information and ideas are presented only with the sincere thought that they may encourage continued efforts toward maximizing diagnostic information with minimal risk to the patient and operator.

Review of the Literature —

Radiation risks have been a concern of radiographers since the invention of radiography. The first case of human injury attributable to ionizing radiation was reported in the literature only a few months after Roentgen published his original paper announcing the discovery of x-rays. However, most of our knowledge of the biological effects of radiation has been accumulated since World War II (HEW REPORT, *The Biological Effects of Ionizing Radiation: An Overview*).

The existence of some degree of radiation risk is not questioned in the literature; however, the exact level of risk has been the subject of widely differing opinions. Because the low levels of radiation used in radiography do not produce any directly demonstrable effects, risk estimates have been limited to statistical assumptions and extrapolations.

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The most authoritative source of information on radiation risks is the Committee on the Biological Effects of Ionizing Radiation (BEIR Committee) of the National Academy of Sciences. The 1979 BEIR III REPORT *The Effects on Populations of Exposure to Low Levels of Ionizing Radiations* recommends that average lifetime individual whole-body exposure to man-made radiation be limited to 10R, which is equivalent to doubling the expected exposure from natural background sources of radiation. Since the greatest source of man-made radiation is therapeutic and diagnostic x-rays in the healing arts, our responsibility to minimize our share of this exposure is clear.

The U.S. DEPARTMENT OF HEW (1980) AND LURIE (1981) address the cancer risks of dental radiation. Lurie states, "there is a carcinogenic risk from any exposure to radiation, no matter how small." Referring to the cancer risks, he states that estimates per million examinations with a full-mouth series are 4–11 for thyroid, 1–3 for salivary glands, and 0.2–1 for brain. He adds that since the latent period for radiogenic cancer is typically 20 to 35 years or more, many patients could die from other causes before the radiation problem arises; however, this also means that these risks are highest in children.

With the development of cephalometrics and other radiographic techniques, the orthodontic specialty has shown continuing concern over balancing the potential risks against the diagnostic benefits.

In 1973, FRANKLIN discussed the risks of scattered radiation. He stated that "as little as 20 rems of exposure to the thyroid region of infants has been related to later incidents of thyroid cancer." Since 20 rems is a hundred times the usual annual background levels to the *whole body*, and a hundred to more than a thousand times the exposure for a cephalometric film, should we still be concerned? Perhaps so.

BLOCK ET AL. (1977) quoted reports of thyroid damage resulting from *therapeutic x-ray treatment*, and measured the thyroid dose in panoramic and cephalometric examinations. They found that a thyroid area receives appreciable doses during panoramic procedures, and presented methods by which the dose could be reduced without affecting the quality of the image. In the child and adolescent, in whom the neck is shorter and the thyroid lies closer to the dental region, one can expect higher doses in these examinations, but they could not determine actual dose levels in children because no child phantoms were available.

Block also noted that if the panoramic field of exposure is positioned higher, thyroid exposure will be lower while eye exposure will be higher.

As recently as September, 1982, an editorial by Watson in the American Journal of Orthodontics expresses concern, noting that low-level radiation can affect cells in three ways -- carconogenesis, teratogenesis, and genetic mutation. Watson further states that we do not know what the health effects are at dose rates as low as a few hundred milliroentgens per year, just a few factors above natural background exposure. It is probable that if any health effects do occur, they will be masked by environmental and other competing factors that produce similar effects. He further expresses concern that lymphoid tissue is particularly susceptible to radiation, and that many of our growing patients have much active lymphoid tissue in Waldeyer's ring in the tonsil and adenoid areas.

PHILLIPS(1973) AND GRAY (1980) express the opinion that, while concern over the potential hazards of radiation is good, the predominance of one-sided and misleading reporting in the lay press and the resulting reactions of regulators tend to instill only fear. Gray states that "radiation is potentially dangerous. It should be used with care and only as indicated, in both clinical and industrial environments. But even more hazardous to the health of the community and the patient is the fear of radiation that is developing in the minds of the public." He goes on to stress that we should educate the public to the benefits as well as the risks of diagnostic imaging.

While most literature is directed primarily at identifying risks, there are also many recommendations for ways to reduce radiation and improve the diagnostic quality of radiographs. Either accomplishment will result in a relative reduction of risk.

Since the risk to the dental staff and to patients, while small and controversial, is still fairly clear, and since the public is becoming more and more concerned, it appears prudent to address the possibilities for minimizing even these small risks while maximizing the diagnostic benefits of orthodontic radiography.

BLOCK ET AL. (1977) recommend restricting the vertical height of the exposure band in panoramic radiography to exclude the thyroid and eyes in children. They believe that a 5″ film width covers the area of interest in the jaws very adequately. They go on to recommend reducing beam thickness as well as height, quoting ANTOKU (1976) that "a measurable reduction in thyroid dose can be achieved when a narrow beam is used." However, beam thickness is a design factor that may not be adjustable in the field.

Block further explains that in cephalometrics there is no way of getting the thyroid out of the picture area, recommending a leaded collar.

At the Fifth International Congress of Dental-Maxillo-Facial Radiology in Portland, Oregon in 1980, many of the papers presented specific methods for reducing radiation to the patient. E. L'ABEE, COLQUITT, HURLBURT, E.F. MILLER AND H. M. WILLIS, MEDWEDEFF, BIRD ET AL. AND SIPPY all presented techniques for radiation reduction.

LURIE (1981) recommends the use of high-speed rare-earth film/screen combinations, ultra-high-speed intraoral films, shielding, beam-guiding field-limiting devices, high kilovolt-peak, thyroid shield, quality assurance programs to maintain optimal machine and processing performance, and high-yield criteria for the ordering and taking of radiographs.

The orthodontist can modify beam dimensions and intensity with collimators and sliding aluminum wedge filters, which can reduce the dose to patients considerably. Many of these measures can also improve film quality. Internal modifications to x-ray equipment must be approved by the appropriate State Radiation Protection Agency, but this applies only to internal modifications, and not to these external additions that further restrict the x-ray emission. Lurie states that by use of a skull for testing and modifying one's own equipment, dose reductions of 50-300% can be achieved.

Lurie adds that diagnostic films should be exposed with optimal techniques, using as few exposures as possible. He is adamant in condemning the use of x-rays for screening examinations for unsuspected occult disease, or for insurance or teaching purposes. Such applications are now banned in some states.

WATSON (1982) summarized as follows: "The best method to reduce the exposure of the patient to x-radiation is to be selective in prescribing x-rays and to use the minimum number of films based on the needs of the individual patient for diagnostic purposes." Some of the most effective means for reducing radiation dose include the following:

- Avoidance of unnecessary exposures
- The highest kilovoltage technique possible
- Close collimation

- Use of beam-guiding and film-holding intraoral instruments
- Wrap-around leaded aprons and thyroid shields
- Operator and environmental protection barriers
- Ultra-speed film
- Minimum exposure time and maximum developing time
- Meticulous darkroom procedures
- Careful examination of the processed film
- Upgrading of equipment; dental radiographic equipment in compliance with federal (NCRP Report No. 35) and state standards.
- Quality assurance program
- Continuing education
- Use of phantoms for teaching

— General Implementation for Radiographic Risk Reduction

The darkroom

. . . is the first area that the Author is concerned about as a practicing orthodontist. Periodic checks should be made to assure that the darkroom is indeed that, a **dark** *room*. Painting the room black can prevent reflection of stray light, but sealing or blocking all outside light is imperative. A helpful hint here is the use of a magnetized, foam-backed seal that automatically seals the door every time that it is closed.

An inside-locking bathroom-type door latch can prevent inadvertent entering of the darkroom while films are being processed. An outside signal light that is turned on with the darkroom safelight to indicate that films are being handled serves as an additional safeguard.

Darkroom safelight filters must be matched to the film being used, and *any* safelight must be tested in actual application. Bulb size, distance and exposure time are all important factors in addition to the correct filter. Of those, exposure time is always a variable, requiring constant care on the part of darkroom personnel.

Chemicals should be adjusted continually to the processing load. In the Author's office, films are tank processed in preference to using an automatic processor. Film quality is better, and the speed of an automatic processor is not required. Intermittent use of an automatic processor for small work loads aggravates the waves and striations that appear on films from the combination of short processing times and roller action.

Correct temperature is another critical variable in proper processing of films, by any method. Automatic controls can fluctuate, so actual temperatures in tank or processor should be checked regularly with an accurate thermometer. Temperature can be controlled by a mixing valve and regular flow of water, but in some areas the warm summer water temperature may necessitate a source of cooled water for tank processing.

Chemical or particulate contamination is another problem in many local water supplies, fogging or clouding films. Distilled or other pure bottled water may be necessary for mixing developer, and filtration may be required in water supply lines.

Correct and consistent timing is the final control required in the darkroom chemical processes, so darkroom timers should be periodically checked against an accurate reference.

Shielding the X-ray Room

Protection of office personnel and the public from stray radiation is an important obligation which may require the addition of protective shielding to the x-ray room.

Each installation must be protected on the basis of actual use, with maximum practical safety in mind. Two levels of protection are required; heavy shielding for the primary beam, and less for scattered radiation. The primary beam should be directed away from occupied areas if at all possible. If this is not possible, any walls that may be struck by the beam should be shielded with lead. For the scattered radiation in other areas, even heavy plasterboard will have a significant attenuating effect, so less supplemental shielding may be required on those walls.

An x-ray room should be designed so that the controls and activating switches are behind a protective barrier. This should be located well away from the primary beam, with sufficient shielding for protection against scattered radiation. Patients can be viewed through a mirror or through leaded glass fitted into the barrier.

Prior to construction of the Author's office, the room which now contains the panoramic and cephalometric units was designed so that two of the walls were exterior concrete block walls, with no nearby human activity. Equipment is located so that the primary beam is directed toward those walls. The remaining two walls were lined with lead from floor to ceiling. The lead was purchased in large rolls that could be glued to the plasterboard. Both doors were also lined with lead foil, which can be glued to the back of any door and covered with plywood.

Patient Shielding

Protection of parts of the body not being radiographed is axiomatic. During all radiographic procedures, front and back lead aprons are used to protect gonad and breast areas in particular, with supplemental protection for the thyroid gland (Fig. 1).

Patient Selection for Radiographic Examination

Unnecessary or unused films should be viewed as a 100% excess exposure. Each patient should be individually evaluated to determine which radiographs are clinically necessary. In the Author's office no "routine" films are taken just because of age or treatment stage; all films are individually prescribed on the basis of a need for specific information related to that person's health care. All films are logged, with a record of exposure factors for future reference.

Films and Screens

Several years ago, the General Electric Company supplied the Author with experimental blue-emitting Rare-earth intensifying screens called Blue Max I and Blue Max II, which were used with high-speed Kodak film. This combination allowed reduction of the radiation exposure for cephalometric and panoramic radiographs by approximately 50% for Blue Max I and 75% for Blue Max II. However, problems of screen stability and graininess led to discontinuation of Blue Max II.

Meanwhile, the 3M Company was developing a green-emitting Rare-earth system of even higher speed. Originally identified as Alpha, these are now being marketed under the Trimax name. The Author's personal experience indicates that Trimax XUD ultra-detail film, used with Trimax 12 screens, yields an exceptionally readable radiograph, with at least a 50%–60% reduction in radiation exposure over conventional high-speed systems. These ratios will vary with kilovoltage and other factors.

Fig. 1 A front/back lead apron shields breast and gonads while a separate collar shields the thyroid.

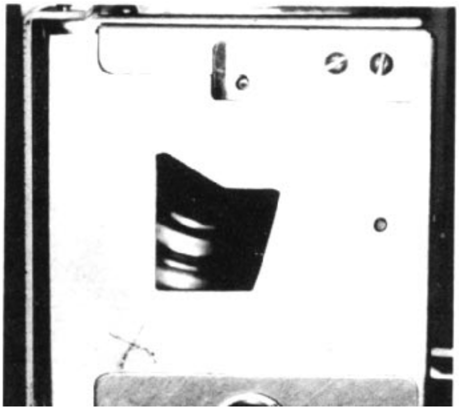

Fig. 2 Facial collimator in place on x-ray tubehead. Fig 4 shows film exposed with this collimator.

Fig. 3 Collimation added to upper part of tube aperture for P-A exposure as shown in Fig. 5

Furthermore, even faster films providing up to 75% *additional reduction* are available for use where maximum detail is not required. These films are used for many progress radiographs or P–A views where unerupted teeth are not a concern. All of these materials can be used with conventional processing chemicals and equipment.

Most recently, a *submento-vertex* view has been recommended for ascertaining condyle angulation. The extra radiation required for this additional film can be quite effectively minimized without loss of important information by using the maximum-speed screen/film combination.

— Cephalometric Exposure Reduction —

As previously described by L'Abee (1980), and stimulated by discussions at the Midwest Angle Orthodontic Meeting in 1981, the Author began using a calibrated skull and movable lead strips to develop a collimator for cephalometric radiography. This facial collimator (Fig. 2) gives precise, uniform collimation of the cranial and posterior areas which are not of diagnostic importance in most cases. A conventional cephalometric radiograph and one exposed with the new collimator and thyroid apron are shown in Fig. 4. Such a collimator can be fabricated individually, or a standardized version can be obtained from the Wehmer Co.

The P-A view requires different considerations in collimation. The areas above the transmeatal axis are of lesser diagnostic value, so this region is screened by the lead strip added across the top of the aperture (Fig. 3). A radiograph exposed with this added collimation is shown in Fig. 5.

The different geometry of the lateral and P-A collimation requires changing collimators for each view. This changeability also makes it possible to leave the added collimation off when diagnostic considerations require a broader view.

As previously mentioned, progress and submento-vertex films are now taken with the fast 3M Trimax XD or XM films, usually in combination with added collimation, to limit the amount of radiation to the patient to the lowest possible exposure.

Fig. 4 ***Top***— lateral radiograph taken with thyroid collar and facial collimator shown in Fig. 2
Bottom— without added collimation

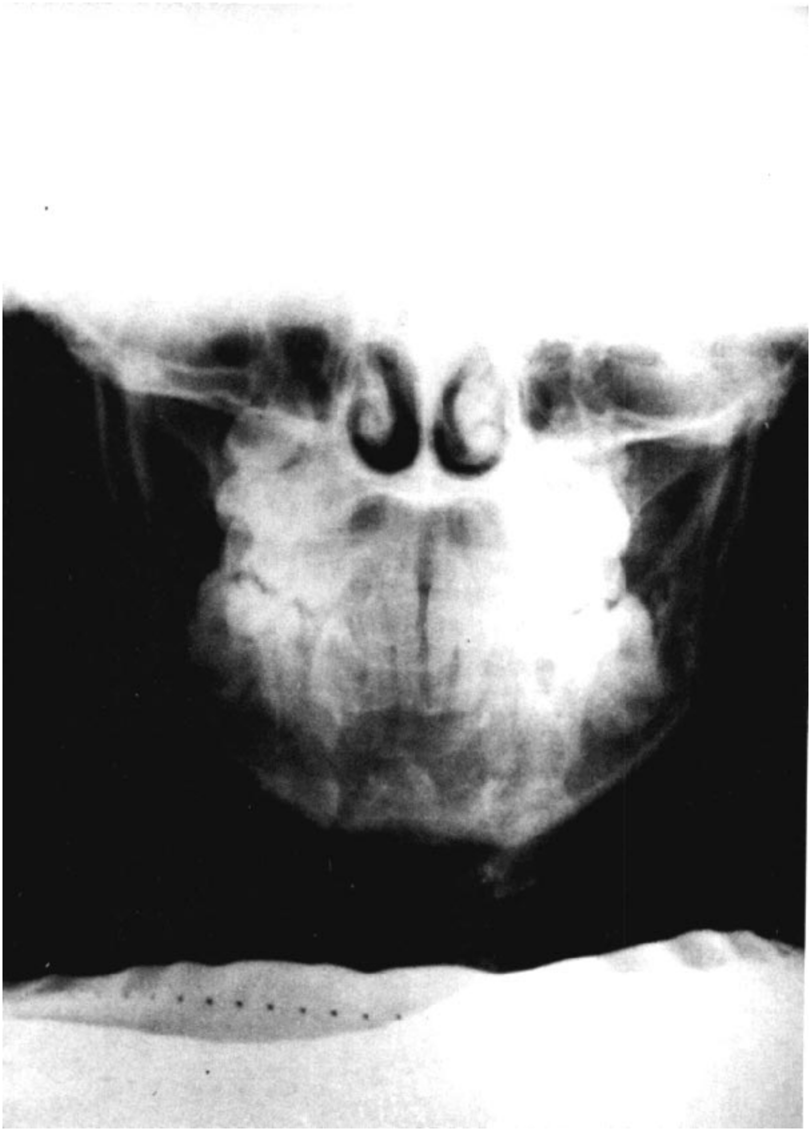

Fig. 5 A postero-anterior (P-A) radiograph exposed with orbital collimation as shown in Fig 3

Fig. 6 Panoramic head positioner — the head is oriented and stabilized by the two earrods and incisor guide. Collimator pointer rods are retracted, ready for the x-ray exposure.

— Panoramic Exposure Reduction —

Head Positioning

Head positioning, we all know, can be just as crucial for proper panoramic radiography as film and tube orientation in periapical radiography. Improper head positioning or improper alignment of the x-ray focal trough with the maxilla and mandible can cause distortions in shape and size that may compromise the diagnostic value of the film enough to require retakes.

In an article titled "Analysis of panoramic cephalometrics using a skeletal cephalostat" (Alpern, 1979), the Author described a panoramic head positioner developed and tested as a thesis subject at the Ohio State University. The results showed that a cephalostat can assure proper head positioning and help center the maxilla and mandible and their related bony bases and teeth into the appropriate focal trough of the Panelipse x-ray machine. This gives a replicable, measurable radiograph that eliminates the most common reasons for retakes.

Exact head positioning with the panoramic cephalostat provides the accuracy needed to measure changes with growth and development, or following orthodontic or surgical therapy. It also assures a panoramic temporomandibular joint radiograph of reasonable accuracy.

The earposts of this device function as conventional cephalometric earposts, preventing head rotation except around the

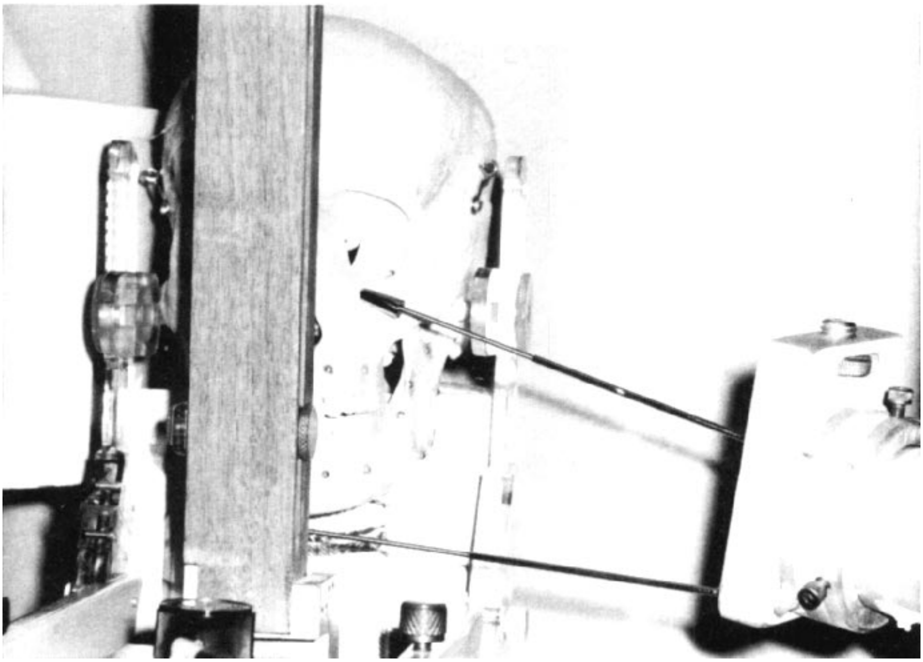

Fig. 7 The panoramic collimator, held in place on the tubehead by thumbscrews. The flat thumbwheel at the top adjusts the upper sliding lead collimator and simultaneously moves the retractible pointer rod to show the upper limit of the x-ray beam. A similar mechanism operates the lower collimator and indicator rod.

earpost axis. Once either the nasion or tooth-borne stop is in place, that rotation is also secured. The patient's head is fixed in a reproducible relationship to the x-ray focal trough, and held steady throughout the twenty-second rotational radiographic process.

Eyes and Thyroid

One very effective method for reducing radiation to the eyes and the thyroid gland appears to be the orbital-thyroid collimator (OTC), developed by the Author (Figs. 6-8). This is essentially a slip-on device that can be added to most panoramic x-ray machines to assure accurate vertical limitation of the thin beam emanating from the tubehead. Adjustments are guided by either telescoping pointers or a light beam, to keep the eye and thyroid out of the primary beam. The two panoramic radiographs in Fig. 9 show no significant difference between films of the skull shown in Fig. 7 made with and without the OTC.

Use of the orbital-thyroid collimator adds only 30 to 45 seconds of operator time. In return, it eliminates concern over radiation to the eye and thyroid gland, and assures the orthodontist of proper alignment of the structures within the x-ray beam that are of diagnostiuc importance. This device is one answer to the concerns of Block et al. (1977) over eye and thyroid radiation in the panoramic procedure.

Fig. 8 Pointer rods show the area of beam coverage on a patient. Fig. 6 shows these pointer rods retracted for the exposure.

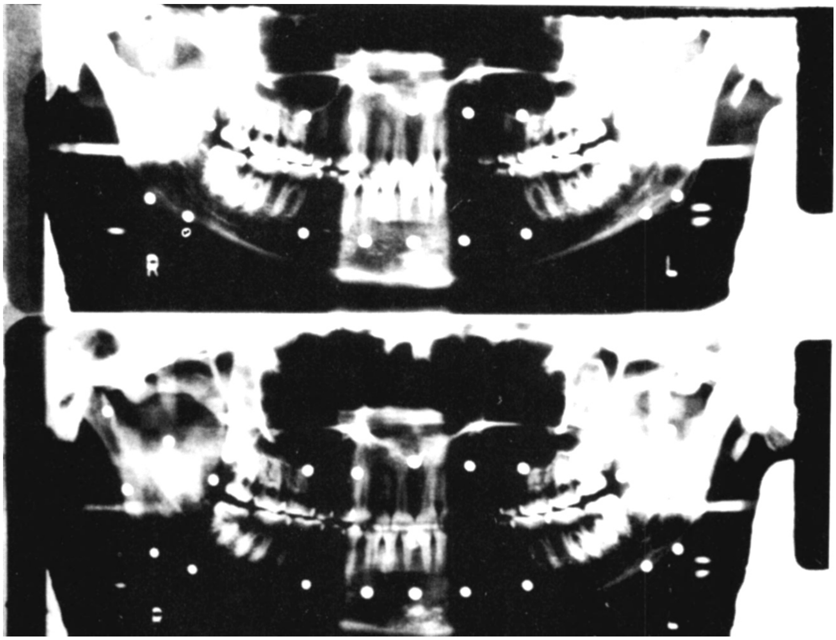

Fig. 9 Radiographs of the skull shown in Fig. 7. Top, collimated with O.T.C. Bottom, no collimation.

— Recommendations for the Future —

It seems quite apparent that radiation reduction and radiation safety must be in the mind of every practicing orthodontist. It is also clear that the public is receiving most of its information through the lay news media rather than from the profession.

Orthodontists must maintain a leading position in the health care field in minimizing radiation to their patients, especially with continuing efforts toward individualized patient collimation. We must also expand our efforts in educating them on the *health benefits* of this low-risk procedure.

Orthodontic graduate programs have an especially large responsibility in this area. There is still a need for more teaching and research time dedicated to radiography in general and radiation reduction for our patients in particular, especially since radiography is the basis for much current clinical research.

Read at the Midwestern Component, E. H. Angle Society, February, 1983.

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