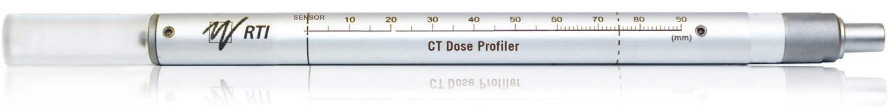
APPLICATION NOTE

Use of constant relation – $CTDI_{100(centre)}$ to $CTDI_w$

This Application Note gives the background for the use of the k-factor to measure $CTDI_w$ by measuring only $CTDI_{100(centre)}$ in a CTDI phantom as expressed in IEC 60601-2-44 edition 3.1. The use of the k-factor handles the $CTDI_{100(periphery)}$ so that the $CTDI_{100(periphery)}$ do not have to be measured during normal QA.



Introduction

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Formerly it was known as a rule of thumb that the relation between $CTDI_{100(centre)}$ and $CTDI_w$ for a head phantom was close to 1.05 and for a body phantom close to 1.7. Extensive scientific work has been done for example by ImPACT, (www.impactscan.org). Based on data from ImPACT, RTI has implemented the k-factor into the Ocean software. With time, based on empirical data, the range of k-factors has been complemented. It has been shown that the k-factor has some dependence for beam energy (kV), why Ocean has individual k-factors for the kV setting on the machine.
In case a k-factor for a machine type is missing in Ocean, there are two options. Either use a generic factor with the consequence that the measuring uncertainty increases, or, for once, take the time to make extensive measurements and calculate the k-factor. Ocean has support for adding user specified k-factors.

Why can a constant be used?

The k-factor is defined as

$$k = \frac{CTDI_w}{CTDI_{100(centre)}}$$

and $CTDI_w$ is defined as (IEC 60601-2-44)

$$CTDI_w = \frac{1}{3}CTDI_{100(centre)} + \frac{2}{3}CTDI_{100(periphery)}$$

the two equations above gives

$$k = \frac{1}{3} + \frac{2}{3}\frac{CTDI_{100(periphery)}}{CTDI_{100(centre)}}$$

With this given, it is clear that the k-factor is based on that the ratio between $CTDI_{100(centre)}$ and $CTDI_{100(periphery)}$ does not change over time.

Below are parameters that has or may have influence on the k-factor.

Focus distance

The most important component that effects the ratio between $CTDI_{100(centre)}$ and $CTDI_{100(periphery)}$ is the focus to skin distance. The inverse square law has a great impact on the dose to skin compared to iso-center. Especially for body phantom where the separation of the center position and the periphery position is 15 cm.
As an example: A machine with a focus to iso-center distance of 70 cm versus one with 80 cm will lead about 10% higher dose in periphery for the 70 cm one, at same dose to iso-center. For shorter focus distances the difference will increase rapidly.

Beam energy

The beam energy has a strong effect on attenuation in the body (phantom). With higher energy the difference between peripheral dose and center dose decreases due to the higher attenuation.

Beam shaping (bowtie) filter

A sharp bowtie filter will to some extent have effect on the periphery dose. However, it is minor due to that the absolute majority of the dose to the point where the dose is measured comes from when the focus distance is shortest. I.e. when it passes the measuring point and thereby is exposed to the central beam. Variation of bowtie filters has shown to have very little influence on the ratio between $CTDI_{100(centre)}$ and $CTDI_{100(periphery)}$.

Collimation (NxT)

The collimation has no or very limited influence on the k-factor. This is explained by the fact that it does not matter where in z-axis the radiation hits the phantom in terms of what amount of radiation hits the center versus the periphery. Exception is for wide collimations where the length of the chamber and phantom is the limiting factors.

Other

Anode angle, filtration, and tube aging will to some extent have influence on the beam energy, and thereby influence the k-factor. Each of them with exception of tube aging are parts of the machine. Effects of tube aging is neglectable in comparison to other influence parameters.

Summary

From above follows the k-factor can be used. Highest precision is achieved by measure the k-factor one time for each machine and setting. But a very good trade off will be to use k-factors given for a machine type and kV setting.

Measurement uncertainty when measure periphery dose with ion chamber

When measure the periphery dose with a pencil type of ion chamber there are some facts that will influence the precision, and repeatability. These has to be taken into account carefully if when measure the $CTDI_w$ in the traditional way, and off course if doing it to get an individual k-factor.
Most important is to make sure that the measured value represents a one lap rotation. Many scanners have an over rotation when using axial mode. I.e. the radiation is on for slightly more than 360°. If the start positon of radiation is just before it passes the ion chamber and the end position is just after the over-reading in a worst case scenario can be close to twice the dose. Taking a large number of measurements and remove out-layers will reduce uncertainty. Care has to be taken to analyze if data is relevant or not.

Conclusion

In comparison to any other method, the measurement of $CTDI_{100(centre)}$ and use of k-factor has great advantages in regards of efficiency as well as over-all accuracy.

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