**Purpose/Objectives**

Radiation epilation (RE) was the mainstay of therapy for ringworm (tinea capitis) in the first half of the 20th century. RE continues to have repercussions today due to the large number of children treated by this technique over 50 years ago and who may still develop radiation induced brain tumors. We therefore reviewed the history of RE for ringworm, in particular the connection with the development of meningioma.

**Materials and Methods:** A search of relevant literature was performed including a Medline search and search of articles referenced in radiotherapy and dermatology textbooks published in the period from 1870-1970 which covered the period before the discovery of radiotherapy until after the use of RE was discontinued.

**Results:** - Tinea capitis prior to X-ray era

Ringworm (tinea capitis) was endemic and considered a major health and economic hazard in several European countries as well as in the USA towards the end of the 19th century. A child affected by ringworm was isolated and socially stigmatized and would often miss school for periods of a year or more. The mainstay of treatment was manual epilation which was painful, time consuming and impractical.

Charles W. Allen: New York 
"should these cases be epilated? Yes, if it can be done with proper skill, care and intelligence, but to start to epilate several hundred children with ordinary hospital attendants is a task much more than useless".

Herbert Alder/Smith: Christ Hospital School UK 1881-1897
Ringworm and alopecia areata: pathology, diagnosis and treatment. London 1881 - epilation should be freely and frequently practiced with a broad flat pair of forceps. 
1897 - apart from epilation - "the treatment of extensive ringworm is still most unsatisfactory. The new remedies are no better that the old ones".

Raymond Sabouraud: Les Teignes, Paris 1894
Described the causative agents, clinical course and treatments available for tinea capitis at the beginning of the 20th century. Incidence of Tinea Capitis reached epidemic proportions. Impact of the disease on public health.
There is no effective treatment against the organisms causing ringworm.
Therefore pilonidal, together with poultices and to aid the epilation, the mainstay of therapy.

December 1895: Roentgen announced the discovery of x-rays, in 1896 -5000 pamphlets and nearly 1000 papers were published on x-rays. 
L R Bowen, 12 March 1896 talk to the London Camera Club - Warning that x-rays might produce sunburn-like effects - Lancet Mar 1896

**Radiation induced alopecia**

March 1896: - John Daniel performed experimental x-ray of skull on Dr William Dudley (dean of Vanderbilt University) before attempt to locate bullet in child’s head with x-rays. The X-rays, Science 3 (April 10, 1896): 162-3 1 hour exposure, 2 inch diameter tube held 5 inch from hair
Outcome - 2 inch circle of alopecia, no inflammation Freudent - 1897 - successfully treated 5 yr old girl with hairy nevus on back.

**Sir Joseph Lister - presidential address -**
British Association for the Advancement of Science, Sept 1898
Roentgen called the radiant energy the x-rays, the rays will and should, of course, be called Roentgen rays, it is found that if the skin is long exposed to their action it becomes very much irritated, affected with a sort of aggravated sunburn. This suggests the idea that a transmission of the rays through the human body may not altogether a matter of indifference to internal organs.

**Treatment of Tinea – after 1896**

Radiation epilation was rapidly adopted and became the treatment of choice wherever it was available, especially during the epidemics in Europe in the early 20th century, in Israel and in the USA during and after the period of the Second World War.

Freund & Schiff 1897 suggested use of x-rays to treat tinea with "fractional doses 2-3 times weekly until a defluxion resulted". The results at first encouraging were negatived by the large percentage of cases of permanent alopecia
Whitfield (USA) - Jan 1903 - Cases of ringworm treated with x-rays
Sabouraud & Noire - 1904 - Depletion at one 4 hour sitting - "Ringworm of the scalp disappearing in France as a result of the new method of treatment" in other countries, especially England. The results were not favorable: percentage of cases of permanent alopecia was too high.
Sabouraud used chromoradiometry pastilles placed directly on patient’s body which change color as a result of exposure to x-rays.
Kienbock: 1907 - 5 field technique modified in 1909 by Adamson "ingenious method of dividing the scalp into 5 areas. Each area given a pastille dose. No protection necessary excepting for the face, ears and neck. The oblique radiation from one area reinforced similar radiation from other areas, thus providing equalization of quantity over the entire convex scalp".

**Treatment Outcome**

Paris Ringworm School (Sabouraud 1910)
Prior to 1903, the average time required for a cure was 27 months.
About 300 cases were hospitalized
About 110 were annually discharged cured.
After institution of Roentgen therapy cure required 6 weeks 327 cases /year
Hospital St Louis: Cost of treatment reduced from 2000 to 260 francs 1906 Assistance Publique recovered 2.5 million francs.
One of the buildings containing 150 beds was returned to the Health Board, saving about $300,000.
"The provincial colonies for ringworm were practically discontinued as all such cases were treated as outpatients at a cost of less than $1 per head.

The Lancet Commission on Ringworm - 1910
Grave prevalence of ringworm: Recommends Sabouraud’s single session over repeated small doses.
Departments in London at: Guys, UCH, St John’s & Metropolitan & London Hospital, Ringworm School treating <1500 cases/year.
"we take it as proved... At the present time the X-ray treatment is the most certain and most rapid method of treatment of the scalp, with care and in the hands of experts no danger is incurred".
He Lancet Commission recommended establishing 4 additional centers in London capable of each treating 700 patients/year.
Mackee 1927 (USA): X-Ray & Radium in the treatment of diseases of the skin Roentgen therapy effects a cure in one sitting, in the majority of cases the child can return to school in a month or two. If the treatment is administered by one who is properly trained in the work there is no danger of any kind to the child.
Unfortunately there are very few free clinics and not many private laboratories in this country where these patients can receive modern roentgen treatment. It is a pleasure to see that the number of physicians taking up this work seriously is increasing and it will only be a question of time when these physicians will become associated with well equipped free clinics.
It would be a splendid thing if the health boards of large cities become interested to the extent of equipping a clinic with modern apparatus...".

US Army x-ray manual - 1927 (Description of KA technique with illustrations) "Reusw- if this contagious disease should gain headway in the army it would be necessary to treat each individual head with the x-ray. There is no other satisfactory treatment and, with a reliable technique the result is certain."

Prior to 1940 reports of its greatest incidence came from England and France, and after the first world war several epidemics were reported in Germany. Epidemic ringworm has appeared in 61 US cities (probably present in 27 additional cities).

Minneapolis which had prepared enough x-ray machines attenuated the epidemic in St Paul City.

The 5-point method of Sabouraud introduced in 1907 remained the standard technique until radiation was replaced by the introduction of Griseofulvin in 1959. RE was used in many countries including Eastern Europe the Middle East and North Africa.

**Tinea Capitis in Israel**

Israel Society of Dermatology 1st conference 1927 devoted to fungal diseases, mainly ringworm. 13% of Jewish schoolchildren and 25% of Arab schoolchildren suffered from ringworm.
Dostrovsky et al, J Invest Dermatol 1955 "In 1959 large proportion of school children in Jerusalem found to be afflicated with tinea capitis. During subsequent years intensive campaign led to almost complete elimination. Therefore, tinea capitis among the settled population, presented only a minor problem. However, every immigration wave, especially from the neighboring countries, brought large numbers of cases." 1936 to 1953 a total of 6,190 cases of tinea capitis were seen and treated.
The main therapeutic method X-ray epilation (5,904 cases) followed by local iodine.
The five point method was routinely used.
194 cases treated by epilation by injection of thallium acetate.
High recurrence rate, (47.6%) and tendency to produce toxic manifestations. With X-ray epilation the recurrence rate was only 2.5 per cent.

**Griseofulvin introduced 1959**

**Danger of radiation –induced cancer realized in late 1950s**

RADIATION INDUCED CANCER IN MAN* 
By BIRD STANFORD CASE, K.B.E., C.B., F.R.C.R., F.F.R.

The risk of radiation induced malignancy amongst patients treated with radiotherapy became apparent during the 1960s and the first case of a brain tumor caused by low dose radiation was reported in 1969.

C Lenore Simpson - 1958 Radiation is a Carcinogenic Agent. CA Cancer J - "Most of the skin cancers which hold radiation are squamous cell carcinomas. In general, they are preceded for several years by a chronic dermatitis characterized by atrophy and sometimes ulceration of the skin. Strauss and Klimgan showed that in adequate routine therapy for ringworm, skin doses vary from 340 to 660 R at different points on the scalp and some 25 per cent of this amount penetrated the skull.

No brain tumors have been reported following therapy for ringworm but the only follow-up surveys of groups of children treated for ringworm are inadequate in number and length of follow-up

**Systematic follow up of children treated with RE**

A series of children treated at NYU have been followed and a large cohort in Israel has shown a significant incidence of radiation induced meningioma.

Despite the wide use of radiation for tinea in many countries, the literature is scant with only sporadic case reports from several countries of meningioma following RE.

**Conclusions:** Ringworm of the scalp was endemic and often epidemic in the Western world during the first half of the twentieth century. Radiation epilation introduced at the turn of the previous century allowed a safe and effective treatment for tinea capitis that was particularly important during epidemics, allowing children to avoid prolonged periods of stigma and loss of schooling. Radiation epilation required expensive equipment and skills and was considered the gold standard of care until the introduction of efficient anti-fungal therapy with Griseofulvin in 1959. The theoretical risks of radiation were raised already in 1896 but the clinical risks of low dose radiation only became apparent in the 1960’s after radiation epilation had been replaced by Griseofulvin. Besides two large series of meningiomas following radiation for tinea capitis reported in the literature there are only numerous case reports. The incidence of meningioma following low dose scalp irradiation may be under-reported despite the widespread use of RE in many countries possibly due to lack of awareness of prior radiation in these patients. A history of prior radiation should be sought in patients presenting with meningioma.