

Brachytherapy until 1903: questions of priority^{*}

The early history of brachytherapy—and, more broadly, of the application of radioactive substances for medical purposes—has been covered in a number of articles (e.g., [1–5]) and at least one recent book, Richard F. Mould’s “Radium History Mosaic”, which, as the title implies, is a collection of vignettes rather than a comprehensive history.[6] Yet errors and questionable claims, especially about the beginnings of brachytherapy, persist. To give just two examples: In an article in “The Lancet” in 2012, Stephen F. Keevil asserted that “[r]ecognition of the biological effects of radioisotopes was soon to give rise, quite serendipitously, to another important area of clinical application. In 1901, [Henri] Becquerel [1852–1908] reported receiving a radiation burn from a piece of radium [...]. This finding paved the way for brachytherapy [...]”.[7] As Mould pointed out in 2007, this is quite a common, yet mistaken, assertion.[6:53]

The other example concerns the “Hermann Strebel medal” conferred by the German, Austrian and Swiss associations for radiation oncology (DEGRO, ÖGRO, SASRO) every two years since 1999 for outstanding achievements in brachytherapy. On the occasion of the award in 2013 it was argued that in 1901[!] the general practitioner Hermann Strebel (1868–1943) in Munich had been the first in the world to use brachytherapy on a malignant tumour by inserting ²⁶²[!]Radium needles[!] with a trocar through an incision in the skin directly into the tumour.[8] Leaving aside the factual errors in this statement, the question remains whether Strebel was indeed the pioneer of interstitial brachytherapy in 1903.

This led me to the slightly suspect search for priorities in the field of brachytherapy from before its “conception” to what could be called its “year of birth”, 1903, by going back to the original publications. The aim is to provide a richer and more reliable account of the earliest phase of brachytherapy, than has hitherto been available.

^{*} This research note benefited from some specific comments by a reviewer for the journal “Brachytherapy”. This version has been slightly expanded on p. 10.

Physiological effects of radium

Before the use of radium (or radium salts, to be precise) for medical therapy could be contemplated, someone first had to notice its physiological effect. Experiments on the possible bactericidal nature of Becquerel rays, using uranium oxide, actually went back to 1897 and led one anonymous “medical correspondent” of the “Revue Internationale d’Électrothérapie et de Radiothérapie” in March 1899 to write of potentially using radioactive plasters to treat skin diseases caused by pyogenic bacteria.[9] Research into radioactive substances as therapeutically useful bactericides would turn out to be a dead end, however,[10] and only after the discovery of radium by Marie Skłodowska-Curie (1867–1934) and Pierre Curie (1859–1906) in Paris at the end of 1898[11] was there a realistic chance to discover an effect of the Becquerel rays on human physiology.

On 7 September 1899 the German journal *Physikalische Zeitschrift* received a brief postscript to an article by Friedrich Giesel (1852–1927), a chemist and pioneer of radioactivity research at the Chininfabrik Braunschweig: “Becquerel rays are also directly visible to the eye. If one puts a strong radium sample close to the eye, then one senses a very distinct glow which can also be sensed, of course, when one closes the eye. This sense of light is probably based on phosphorescence within the eye itself”. [12] A few weeks later Giesel also told a large congress in Munich, attended by scientists and physicians, about this phenomenon and thus initiated research on the use of radioactivity in ophthalmology.[13:139] By this time his observations had been confirmed by experiments on his wife Martha (1863–1951), and by his friends and colleagues Julius Elster (1854–1920) and Hans Geitel (1855–1922), both teachers and researchers in nearby Wolfenbüttel; moreover, the Curies also replicated his results after receiving a letter from Giesel, as he wrote to Elster on 15 December 1899.[14:123]

The next report of a physiological effect produced by radium came from the Braunschweig dentist Friedrich Otto Walkhoff (1860–1943), another friend of Giesel’s. He had been loaned 0.2 gr of radium (worth nearly 1,000 Mark at the time) by the latter and had noticed that two exposures of 20 minutes each of his arm to this sample resulted in an inflammation similar to one caused by long exposure to X-rays. He first spoke about this at an amateur photographers’ club in Munich, then published a short note on radioactivity in a photographers’ journal in October 1900.[15] (Further experiments by Walkhoff at the Institute of Hygiene at the University of Munich were stopped by its director Hans Buchner (1850–1902) who declared radium to be a “fraud and completely unimportant”. [16]) Af-

ter hearing from Walkhoff, Giesel tried this, too, and published a paper on the phenomenon.[17] His physician Alfred Sternthal (1862–1942) confirmed Giesel's findings at a congress of dermatologists in Breslau in May 1901.[18]

Walkhoff and Giesel used quite strong radium bromide in a celluloid capsule. This might explain why the radiologist Leopold Freund (1868–1943) in Vienna had not achieved similar results when he had experimented on himself in mid-1900. According to his report on 12 July 1900 to the Austrian Academy of Sciences[19:630ff] he had enveloped the radium—which was rather weak to begin with, as he explained later[20:438]—with a thick aluminium sheet before putting it on his arm for three days. The slight reddening of the skin he attributed to the gutta-percha with which he had covered the aluminium sheet.[19:634]

Becquerel and the Curies undertook such experiments only after they had learned of Walkhoff's and Giesel's discoveries, as they freely acknowledged at a session of the French Academy of Science on 3 June 1901.[21:1289]

Lupus and the beginnings of surface brachytherapy

In the latter half of 1900 the idea of using radium for therapy very slowly seems to have taken shape. Around this time Francis Henry Williams (1852–1936) received a radium sample from his brother-in-law William Herbert Rollins (1852–1929), both in Boston, as the latter reported in 1902.[22] However, their radium chloride, contained in a metal disc, was too weak to be of much use.[23] On 22 November 1900 the *Deutsche Medizinische Wochenschrift* published a short "preliminary notice" by Hermann Strebel that, inter alia, he was experimenting on the bactericidal properties of uranium and radium, keeping in mind that this might have therapeutic value for some skin diseases.[24]

After repeating his hope of using radium for therapy in an article published early in 1901,[25:131] Strebel very briefly mentioned in a discussion on 30 May 1901 at the Breslau congress of the German Dermatological Society that he was currently treating lupus (he does not specify which kind) with Becquerel rays and that there seemed to be some effect as the nodules became paler and less tense.[26:488] A week later, on 6 June 1901, Strebel published a paper on light therapy in the *Deutsche Medizinische Zeitung*, stating at the end that he was using radium in a grease-proof paper capsule to treat lupus and that the results looked promising.[27]

This seems to have been the first time that anyone claimed in print to be carrying out radium therapy. Co-incidentally, on the same day Henri-Alexandre Danlos (1844–1912) told a regular dermatologists' meeting in Paris among other things that, together with Paul Bloch, he was treating a patient with lupus pernio using Finsen light, i.e. ultraviolet light, and radium, although it was still too early for results.[28:577]

Apparently there is no further information on their patient, whereas Strebel admitted at a congress in Hamburg on 26 September 1901 that after 14 days of exposure “ugly inflammations” had occurred which took four weeks to subside, but that the lupus itself had remained unchanged.[20:448] Later he would blame this on the rather weak radium available to him at the time.[29]

At another meeting of dermatologists in Paris on 7 November 1901, Danlos and Bloch reported exclusively, and more detailed, on two cases of lupus erythematosus they were treating with radium chloride obtained from Pierre Curie. Prospects seemed to be good, although they were careful not to claim a cure. However, they already noted three “advantages” of radium: “activité, simplicité, innocuité” (the latter referring to the absence of painful reactions, in contrast to light therapy).[30]

Studies on lupus verrucosus[31] and lupus vulgaris[32] followed and radium was added to the arsenal against lupus—with “excellent” results,[33] as was claimed at the end of 1902 in France following a thesis written by Armand Blandamour who had studied nine cases, some of them by observing Bloch.[34] While Blandamour was cautious about whether the ulceration caused by radioactivity would offer a long-term cure of lupus, he essentially repeated Danlos' claims of the advantages of radium: “rapidité, simplicité”, and “[g]énéralement inoffensives et d'une innocuité parfaite”. (Danlos himself was also reported as slightly guarded about the long-term therapeutical effects, the “absolute cure”, in a journalistic article published in November 1903.[35:15])

In fact, it should remain open when the first patient with cutaneous tuberculosis, even more so with lupus erythematosus, was actually cured with radium alone. Doubts were raised in 1903 by Henri Halkin (1876–1945) in Liège, who had tried to repeat the experiments by Danlos and Bloch.[36] However, a renewed study by Kurt Strassmann (1874–?) at the same clinic in Breslau where Halkin had done his research asserts that the latter's barium radium bromide had to be considered contaminated and thus ineffective.[37] Wilhelm Caspari (1872–1944)[38] in

Berlin and Christopher Michael O'Brien (1861–1935)[39] in Dublin, too, would doubt at the beginning of 1904 that radium was better against lupus vulgaris than the more established remedies, especially Finsen light, although they did not deny the effects of radium. In 1908, the Hamburg physician Paul Wichmann (1872–1960) would claim that using radium irradiation against the “Volkskrankheit” (widespread disease) lupus vulgaris was something of a French specialty, even though he had used it, too, with some success.[40:443f]

Ulcus rodens, other neoplasms and surface brachytherapy

Several reasons can be given why radium therapy took off slowly: radium was expensive and hard to get (three years after Walkhoff's remark, the price in Germany had risen by about two thirds)[41]; it could only be used on the skin yet; moreover, it had to compete with uv light, X-rays, and electricity, all methods that were still fresh enough to be exciting.

In 1903, however, interest in radium exploded and “[e]verybody in the scientific world is buying radium [...]”, as William Crookes (1832–1919) in London wrote in a letter on 20 June 1903.[42:386] In the medical world, treatment of ulcus rodens (basal-cell carcinoma) by radium started to spread. While James Harry Sequeira (1865–1948) claimed in 1915 to have treated ulcus rodens with radium “[a]s far back as 1902”,[43] there does not seem to be a contemporary record of this feat. The earliest cases to be published seem to have been those treated by S. W. Goldberg (Semen Viktorovič Gol'dberg, 1874–1940) and E. S. London (Efim Semënovič London, 1869–1939) in Saint Petersburg, Russia, who began therapy on one of their two patients on 24 March 1903.[44] London later mentioned that they could not follow up on his treatment, but that the second case could not be considered a permanent cure.[45] (Goldberg published his thesis on the physiological effect of Becquerel rays in 1904,[46] but this work has not been available to me.) Treatment of ulcus rodens during 1903 was also reported, for example, from Graz (Karl Kreibich, 1869–1932)[47:448], Glasgow (John Macintyre, 1857–1928)[48], and Boston (Francis H. Williams)[49].

Other neoplasms were also attacked by applying radium to the skin, but therapeutical results turned out to be mixed. Alfred von Exner-Ewarten (1875–1921) in Vienna described nine cases of carcinomas and melanosarcomas treated by him since the end of April 1903, of whom only one had turned decisively to the better, even though metastases on several patients had shrunk due to the treatment.[50] However, these were inoperable cases, so chances had been low from

the start. (Several authors besides Exner stressed that anything that could be operated upon should be so treated in the case of cancers, with the possible exceptions of flat surface carcinomas. In all other cases Röntgen and radium rays were seen as a last attempt, or explicitly as a palliative measure; e.g., [47:448; 51; 52].)

Some doctors, such as Henry George Plimmer (1857–1918) in London, reported no success with radium at all.[53] As William Williams Keen (1837–1932) from Philadelphia put it: “Whether it be due to a difference in the quality of the radium, a difference in the character of the growths, or my method of doing it, or what not, I do not know; but to sum up my experience I will say that in not a single case has there been the slightest benefit with the exception of one symptom, and that is pain”.[54] Radium as an analgesic, though, was recommended by Armand Darier (1854–1927) in Paris in a lecture on 6 October 1903, for example in the case of an epithelioma that was piercing the orbit.[55; 56]

A wide range of dermatological afflictions, from psoriasis vulgaris gyrata[57] to the common wart,[58:254f] were also treated at least since 1903 with radium, often simply to test how it compared to x-ray or light therapy.

Intracavitary and intraluminal brachytherapy

Already in September 1901, Caspari and the Berlin physicist Emil Aschkinass (1873–1908) had ventured the thought that radium, if it was truly bactericidal, could be put inside the body to fight bacterial infections directly at their origin.[59:618] In light of later statements it seems that they might have been thinking of injecting radium (see below), but their idea was expressed vaguely enough to also cover intracavitary and intraluminal brachytherapy.

A brief note in the 4 October 1902 issue of *The Journal of the American Medical Association* also mentions the future opportunity of using radium to treat “[...] some cases of internal and quasi-internal cancers, such as that of the cervix uteri [...]”.[60]

Strebel claimed in 1903 that he had tried to treat a patient with gonorrhoea by using a urethral catheter with radium at its tip and that he had told participants of a conference in 1902 about it,[29] but this was not recorded at the time.[61]

The first truly intracavitary brachytherapy seems to have started in Brussels in the second half of May 1903. Victor Delsaux (1861–1917) showed a meeting of the Belgian Otological Society on 7 June 1903 a malleable rod with a radium cap-

sule at its tip for use in the upper respiratory tract and told his audience that he had already been treating a patient for lupus laryngitis in 19 sessions, with good results so far, and had also very recently begun treating patients with atrophic rhinitis and tuberculous laryngitis.[62]

Shortly thereafter, Exner in Vienna mentioned in a presentation on 26 June 1903 that he had begun to irradiate a tumour on the left side of the arcus palatoglossus (oral cavity) only a couple of days before.[63] At the same meeting his colleague Guido Holzkecht (1872–1931) also hinted at recent experience in applying radium to mucous membranes in body cavities,[57] but no more information was given there or in the report of his lecture on the application of radium to skin and mucous membranes at a dermatological congress in Sarajevo on 23 September 1903.[47:447f] In late August or September 1903 James Mackenzie Davidson's (1857–1919) in London irradiated an epithelioma which had invaded the hard and parts of the soft palate by fastening two or three tubes filled with radium to a "narrow strip of thick lead".[64]

Margaret A. Cleaves (1848–1917) used radium in New York on 15 and 16 September 1903 on an "inoperable primary pelvic case of epithelioma". Cleaves first inserted the glass water-jacket of a vaginal x-ray tube into the cervix uteri and then put the radium tube inside the water-jacket.[65] In an article published on 16 October 1903 William James Morton (1845–1920) from New York presented various apparatus for radium treatment within, for example, the throat or vaginal cavity.[66:293] His article does not give details on whether he had already used them, but Truman Abbe (1873–1955) told the Medical Society of the District of Columbia on 11 November 1903 that Morton reported "three cases of cancer of the cervix, or post-operative recurrences, under radium treatment, with better results than he was able to get with X-rays".[67:373] Truman Abbe also mentioned that a Dr. Wagner (probably Rome V. Wagner (1869–1908)) in Chicago, Robert Abbe (1851–1928) in New York, and he himself had been treating a cancer of the rectum, an uterine cancer, and a cancer of the cervix and vagina, respectively, with results ranging from "success" via "distinct improvement" to pain relief, at the least.[67:373f] The gynaecologist Albert Döderlein (1860–1941), then in Tübingen, also seems to have attempted to treat inoperable carcinomas with radium in 1903, although without success.[68:209]

By October 1903 Exner in Vienna used a bougie with radium at its tip to treat carcinomas of the oesophagus, apparently the first case of intraluminal brachytherapy.[50:308; 69]

Intratumoral application (interstitial brachytherapy)

As far as can currently be ascertained, Alexander Graham Bell (1847–1922) was the first to propose inserting a glass tube filled with radium into a tumour to eliminate the problem of absorption of radiation by the skin. He did so in a short letter written on 21 July 1903 in Baddeck, Nova Scotia, to the physician Zachariah Turner Sowers (1847–1919) in Washington/DC, which, together with the reply by Sowers, was reprinted on 31 July 1903 in *Science*[70] and on 15 August 1903 in *American Medicine*.^[71] (It should be mentioned, however, that Jan Kazimierz Danysz (1884–1914) had already reported on 16 February 1903 in Paris that he had temporarily inserted radium in a small glass tube under the skin above the backbones of a mouse and of a guinea-pig as well as, after trepanation, into the dura mater of a rabbit to study the effects of radiation.)^[72]

Unknown to each other, in November 1903 two physicians on two continents started intratumoral application of radium in practice, although with different aims. One of them was Robert Abbe in New York, who reported at the meeting of the American Surgical Association held in St. Louis/MO from 14 to 17 June 1904 on several cases of treating patients with radium. One of those cases would become well-known: eight months before the meeting, i.e. in October 1903, a young man of 17 had come to Abbe with a giant-cell sarcoma of the lower jaw.^[58:256ff] (Abbe would write later that it had been a myeloid tumour. ^[73:219]) After treating the patient by surface application of radium with some success, Abbe decided to cut into the tumour with a knife and insert a glass tube containing radium. While he does not give exact dates, a rough timeline can still be drawn up, showing that the 15 sessions—most of the time using a new entry point—went on from November 1903 to January 1904.^[58:257f] At the time of Abbe's lecture the patient was making good progress; in 1920 Abbe was able to state that his patient had been completely cured in a way that would have been impossible with surgery: for example, the jawbone had reossified.^[73:219]

Unlike Abbe, Carl (also written Karl) Blauel (1872–1931), then a physician at a clinic in Tübingen, has been practically forgotten in the history of medicine. He published the results of his experiments on radium effects only in 1905,^[74] without explaining why publication had been delayed, yet his thorough documentation allows us to date his work precisely. Blauel did experiments on animals and humans, not for therapy, but for understanding the effects of radioactivity. Blauel's human patients included two cases of inoperable metastatic breast cancer, another case of breast cancer where the patient for some time refused surgery, yet

another where radium was applied two days before the operation, and one case of inoperable testicular sarcoma. As Blauel assumed that radium would take effect only superficially, he decided—allegedly on the advice of Paul Eduard von Bruns (1846–1916), the clinic's director—to insert the radium into the tumour. He first contemplated using aluminium rods, but even the smallest ones were of no use. He then had small glass capsules formed like lancets made, which were filled with radium and closed by melting at the radium supplier, the Braunschweiger Chininfabrik (Giesel's workplace). In every case he made a deep cut under local anaesthesia, put in the capsule with a string attached, and loosely sewed up the wound. Up to 24 hours later the capsule was removed; amputation and histological inspection of the tissue samples followed.[74:164ff]

Blauel's first case was the sarcoma testiculi utriusque: exposure began on 4 November 1903, for 15 hours. The other cases were irradiated from 11 to 12 November, 10 to 11 December, 16 to 17 December 1903, and from 2 to 3 January 1904.[74:167ff] Blauel came to the conclusion that radioactive radiation killed only the tumour cells, but that its effect in depth, even inside a tumour, was lacking.[74:183]

At a time when both Abbe and Blauel were already practicing it, Walther Scholz (1871–1947) held a lecture on 30 November 1903 in Königsberg in Prussia where he proposed putting small particles of radium into tumours, especially those deep inside the body, also alluding to injections.[75]

Finally, on 24 December 1903, Strebel published his paper "Proposals for radium therapy" in the *Deutsche Medizinische Zeitung*.^[29] Giving an impression that this had already been tested ("I am now able to markedly increase the efficacy of radium for deep-seated pathological processes using the following procedure [...]"), he advocated puncturing the skin with a trocar and then inserting a small aluminium rod with a radium-filled drilled-out tip into a tumour. "There is something to be said for this procedure especially perhaps when treatment is concerned of, for example, a carcinoma which is located in the rectum".^[29]

Yet there are several signs that he had not actually done this. There is no information whatsoever about a patient and the specific tumour on which Strebel would have operated. Some phrases he uses show that he was writing hypothetically: "[...] so I produce a small wound which [...] probably should not give reason for concern".^[29] At the end of his "Proposals" he is careful to note that it would be "up to the future" to see whether such "therapeutical intentions" (also includ-

ing radioactive water, etc.) could be realised successfully. “My own trials in this direction are not yet finished and will be the subject of a later report”.[29]

However, in two publications touching on this topic in 1907 and 1908 Strebel essentially repeats what he wrote in 1903, without any further information.[76; 77:219] In short, Strebel was, neither the first to propose interstitial brachytherapy, nor the first to carry it out; moreover, he very likely never undertook it at all, presumably also because he did not have suitable patients, as he had admitted in a somewhat similar case at a congress in 1901.[26:476] (The erroneous claim that Strebel had treated two patients for sarcoma, made in a previous paper,[78:255e] was due to my failing to notice that Strebel was quoting someone else there.)

Afterloading and crossfire

Even though his purpose may have been somewhat different from current safety concerns,[79:480] Strebel can be credited, on the other hand, with coming up in his 1903 “Proposals” with the, still inchoate, idea of (manual) afterloading by suggesting to first puncture the skin with a trocar and then to insert the radium through the cannula.[29]

Whether his idea of using that first puncture to poke around inside the tumour to irradiate it from several angles[29] should count as a predecessor of the crossfire technique is rather questionable, however. What might be called “successive crossfire” was already being done by Abbe by using multiple incisions,[58:258] and was also practised in surface brachytherapy: Richard Werner (1875–1945) and Georg Hirschel (1875–1963) in Heidelberg, for example, reported exposing a breast cancer at 32 spots five to six times within 24 days.[51] Much more intriguing in this regard is Mackenzie Davidson’s report that he had treated patients in 1903 with several radium tubes simultaneously.[64]

Radium injections and “radium emanation”

In 1901 Aschkinass and Caspari had thought about putting radium inside the body as a countermeasure to bacterial infections,[59:618] as has already been noted. Later the purpose seems to have changed. Based on proposals by the director of his clinic, Ernst von Leyden (1832–1910)—although this may have been the customary nod to one’s boss—and by Caspari[80] who was present at the treatment with Ferdinand Blumenthal (1870–1941), Fritz Meyer (1875–1953) in Berlin reported that on 5 July 1903 he had injected barium radium sulphate in

suspension into a tumour that had recurred in scar tissue after a mastectomy.[81] (Metastases had also developed elsewhere, so the outlook was very poor.) A reaction set in after three weeks and a further injection, and from the beginning of September 1903 the tumour was drained for several weeks. Some of the liquid was used to produce an “anti-cellular serum” in rabbits, which was then injected into another nodule of the patient’s,[81] consciously following up on the anti-cancer serotherapy introduced by Jules Héricourt (1850–1938) and Charles Richet (1850–1935) in Paris in 1895.[82] The radium, and this serum, apparently showed a local effect, but the patient still died because of the lung metastases and general exhaustion.[81] The Berlin biochemist Carl Neuberg (1877–1956) stated the obvious arguments against radium injection in an article published just ahead of Meyer’s: the difficulty of correct dosage, and the loss of expensive radioactive substances.[83:172]

On 25 July 1903 Frederick Soddy (1877–1956) in London proposed letting people with tuberculosis inhale “radium emanation” or “thorium emanation” (both later recognised as isotopes of radon), which might be understood as a form of intracavitary brachytherapy.[84] Although Strebel had made quite similar proposals at the end of 1903,[29] using radium emanation would become a topic in 1904 with the work of Albert Braunstein (Al’bert Petrovič Braunštejn, 1872–1961) from Moscow. In January of that year he had begun to treat carcinomas, either with injections of distilled radium chloride solution, or with bismuth oxynitrate powder that had been kept near radium bromide for several days.[85] Writing in September 1904, Braunstein argued that radium therapy of carcinomas had already become widespread, but that “the numerous reports” showed that radium was not able to cure cancers; instead, radium emanation would heal cancers without damaging normal tissues.[85:413]

Conclusions

To summarise the important “firsts” in brachytherapy up to the end of 1903: physiological effects of radium were first reported in Germany in 1899 and 1900 (Giesel and Walkhoff). Initial attempts at therapy were made public, *en passant*, nearly simultaneously in Germany (Strebel) and France (Danlos) in May/June 1901. When the first patient could actually be considered “cured” by brachytherapy alone remains open; perhaps it was Abbe’s case of giant-cell sarcoma. (Macintyre was rightly sceptical at the end of 1903 about claims of cures.[52]) Intracavitary/intraluminal brachytherapy was first practised by Delsaux in Belgium since May 1903, then Exner and perhaps Holzknecht in Austria in June and

Cleaves in the US in September 1903. Whether to privilege Abbe or Blauel for the first intratumoral application in November 1903, and whether to consider the radium injections by Meyer in July 1903 as intra-tumoral application, is a matter of personal choice; Abbe, however, undertook it for therapeutical reasons and could prove his success.

At that stage many important features of brachytherapy could therefore be discerned, if sometimes vaguely. Radium treatments were attempted on various diseases all over Europe and in the US; the number of patients began to grow beyond single digits. On the other hand, understanding of what went on physiologically was still poor, indications (and contraindications) had yet to be established, and application tended to be haphazard.

In general, even though there was interest in radium, especially because it was such a compact source of radiation, the high price, the lack of reliable dosimetry,[86:457] and the concomitant risk to healthy tissue meant that it was still a niche method within radiology which itself was just striving to be recognised internationally as a separate field.[87] In 1903, Leopold Freund wrote in his radiology textbook: "Whether these [Becquerel] rays will be used in practical therapy is up to further findings. Currently they are only of scientific interest [...]".[88:290] And yet, by the end of 1903 brachytherapy's pre-natal phase had already ended; it had come into the (medical) world and now had to find its place there.

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