

Appendix C:

Evidence Table

American Radium Society® (ARS) Appropriate Use Criteria (AUC) for Adjuvant Radiotherapy for the Prevention of Recurrent Hypertrophic Scars/Keloids

Ref #	Reference	Study Type	Patients/Events	Study Objective (Purpose of Study)	Study Results	Study Quality
23	Li Q, Chen Z, Zou X, et al. Effectiveness of postoperative superficial radiotherapy following the keloid-cross-flap surgery for auricular keloid: A prospective cohort study. Radiother Oncol. Oct 2024;199:110425. doi:10.1016/j.radonc.2024.110425	Prospective cohort	In this prospective cohort study, auricular keloid patients were consecutively screened from January 2019 to December 2021. They underwent keloid-cross-flap surgery and then enter either the superficial radiotherapy or the compression treatment group. The primary outcome was the one-year keloid recurrence rate. Secondary outcomes included: non-completion rate of adjuvant treatment; Patient and Observer Scar Assessment Scale (POSAS) scores and auricular aesthetics scores, evaluated by a four-point Likert scale (1 = poor to 4 = excellent) of non-recurring patients. Propensity score matching (PSM) was used to eliminate potential confounding factors.	To compare the effectiveness of superficial radiotherapy versus compression therapy after keloid-cross-flap surgery.	123 patients were included in the superficial radiotherapy group and 128 in the compression treatment group. Non-completion rate was significantly higher in the compression treatment group (17.97 %), while the loss rate was comparable between the two groups. Overall, 13 patients (13.54 %) relapsed in superficial radiotherapy group, while 22 patients (25.58 %) in compression group (p < 0.05). After PSM, 59 patients in each group were analyzed, and the recurrence rate was lower in the superficial radiotherapy group (13.56 %). Of relapse-free patients, no significant difference was found in PSAS scores, OSAS scores or aesthetic scores between the two groups.	2
46	Arima J, Dohi T, Kuribayashi S, Akaishi S, Ogawa R. Z-plasty and Postoperative Radiotherapy for Anterior Chest Wall Keloids: An Analysis of 141 Patients. Plast Reconstr Surg Glob Open. Mar 2019;7(3):e2177. doi:10.1097/GOX.0000000000002177	Prospective cohort	All consecutive patients with single or multiple anterior chest wall keloids who underwent keloid excision, tension-reducing suturing, z-plasty, and postoperative radiotherapy in 2013-2016 in Nippon Medical School were included in this case series study. Only keloids that arose from small injuries such as folliculitis or acne were selected. The surgery was followed by tension-reducing self-management of the wounds with silicone tape and steroid plaster. The postsurgical radiotherapy modality was 18 Gy administered in 3 fractions over 3 days. The primary study outcome was keloid	To report outcomes for patients undergoing z-plasty and postop RT for anterior chest wall keloids	In total, 141 patients with 141 lesions were enrolled. Of the 141 lesions, 15 (10.6%) recurred. All recurrences were successfully treated by steroid plaster and steroid injection. The recurrence patients did not differ from the nonrecurrence patients in terms of the size of the original keloid or gender distribution.	2

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			recurrence during the 24-month follow-up period. Recurrence was defined as the development of stiff and red lesions in even a small part of the scar that did not respond to 6 months of steroid plaster therapy.			
48	Seth I, Gibson D, Marcaccini G, et al. Post-excisional radiotherapy for keloid treatment: A systematic review and meta-analysis. J Plast Reconstr Aesthet Surg. Feb 2026;113:459-531. doi:10.1016/j.bjps.2025.11.016	Systematic review and meta-analysis	A systematic review was conducted from inception to June 2024. Studies were included if they involved keloid patients treated with post-excisional radiotherapy (X-ray, brachytherapy, or electron beam), applied either early (≤ 24 h post-operation) or late (> 24 h). Studies without data on recurrence or complications were excluded. Outcomes were analysed using rate ratios (RR) with statistical significance set at $p < 0.05$.	To evaluate the effectiveness and optimal timing of post-excisional radiotherapy in preventing keloid recurrence.	Of 3076 records identified, 2507 unique studies were screened, and 106 met the inclusion criteria. These studies involved 10,745 keloid lesions. The mean patient age was 35 years, with a nearly equal gender distribution. Recurrence rates were 18% (X-ray), 14% (brachytherapy), and 16% (electron beam). Complication rates were 9%, 18%, and 16%, respectively. No statistically significant difference in recurrence or complications was observed between radiotherapy modalities or between early and late radiotherapy application ($p > 0.05$ across all subgroups).	M
49	Mankowski P, Kanevsky J, Tomlinson J, Dyachenko A, Luc M. Optimizing Radiotherapy for Keloids: A Meta-Analysis Systematic Review Comparing Recurrence Rates Between Different Radiation Modalities. Ann Plast Surg. Apr 2017;78(4):403-411. doi:10.1097/SAP.0000000000000989	Systematic review and meta-analysis	A literature review was performed from 1942 to October 2014 using the databases: PubMed database of the National Center of Biotechnology Information, MEDLINE, Biosis, Embase, Google scholar, and Cochrane database. Articles were reviewed for case numbers, patient demographics, keloid location, follow up, radiation modality, dose, keloid recurrence, and complications.	To review the radiation-based treatments (brachytherapy, electron beam and X-ray) used for keloid management and compare their outcomes.	A total of 72 studies met the inclusion criteria representing 9048 keloids. These studies were categorized by treatment: brachytherapy, electron, or X-ray. Meta-analysis demonstrated that radiotherapy after surgery had less recurrence when compared to radiotherapy alone (22% and 37%, respectively, $P = 0.005$). Comparison between modalities revealed that postoperative brachytherapy yielded the lowest recurrence rate (15%) compared with X-ray and electron beam (23% and 23%, respectively; $P = 0.04$, $P = 0.1$). Subgroup analysis by location demonstrated chest keloids have the highest recurrence rate. The most commonly reported side effect of radiotherapy was changes in skin pigmentation.	M
50	Yossi S, Krhili S, Mesgouez-Nebout N, et al. [Adjuvant treatment of keloid scars: electrons or brachytherapy?]. Cancer Radiother. Feb 2013;17(1):21-5. Traitement postopératoire des cicatrices chéloïdes : électrons ou irradiation interstitielle ? doi:10.1016/j.canrad.2012.11.002	Retrospective	From 1994 to 2010, 95 patients with 142 keloid scars have been treated by immediate perioperative irradiation and retrospectively reviewed in our institute: 116 scars were treated by electrontherapy and 26 by brachytherapy.	To evaluate perioperative treatment of keloid scars with electron beam therapy or iridium 192 low dose rate brachytherapy.	In the electrontherapy group treated locations were: earlobe ($n=88$, 76%), thorax ($n=14$, 12%), neck ($n=9$, 8%), limbs ($n=5$, 4%). The median size of lesions was 3cm (range [R]: 0.5-18cm). In 95.6% of cases, a dose of 15Gy was delivered in five fractions of 3Gy. The median follow-up was 70 months (R: 7-161 months). The 2-year and 5-year local control were respectively 69% (95%	3

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					confidence interval [95% CI]: 59-76%) and 55% (95% CI: 45-64%). In the brachytherapy group treated locations were: neck (n=3, 11%), earlobe (n=8, 32%), abdomen (n=3, 11%), thorax (n=2, 8%), limbs (n=10, 38%). The median size of lesions was 6.6cm (R: 1.7-28cm). The median dose delivered at 5mm from the source was 20Gy (R: 15-20.69). The median follow-up was 113 months (R: 21-219 months). The 2-year and 5-year local control were respectively 84.6% (95% CI: 64-94%) and 73.5% (95% CI: 49-87%). So far, no radiation-induced cancer has occurred. A trend to a better local control with brachytherapy was noted (compared to electrontherapy, 2-year relapse is halved with brachytherapy) though this difference did not reach the significance (P=0.0991), probably due to the reduced number of patients in the brachytherapy group.	
51	Flickinger JC. A radiobiological analysis of multicenter data for postoperative keloid radiotherapy. Int J Radiat Oncol Biol Phys. Mar 15 2011;79(4):1164-70. doi:10.1016/j.ijrobp.2009.12.019	Systematic review and meta-analysis	A comprehensive literature review was performed to compile a database of 2,515 resected keloids (36.9% earlobe). Postoperative XRT was 45- to 100-kV X-rays in 27.0% or 120- to 250-kV X-rays in 11.1%, Co-60 in 1.9%, Sr-90 in 4.7%, 1.5- to 9-MeV electrons in 26.5%, and no XRT in 28.8%. In the 1,791 irradiated patients, the median radiation parameters were as follows: total dose, 15 Gy (range, 6-30 Gy); dose per fraction, 5.0 Gy (range, 2-15 Gy); fractions, 3 (range, 1-10); and time, 7 days (range, 0-33 days).	To identify factors significantly affecting recurrence rates after postoperative external beam radiotherapy (XRT) of keloids, and to delineate any radiation dose response and effects of radiation dose per fraction.	Multivariate stepwise logistic regression correlated decreased keloid recurrence with earlobe location ($p = 1.98E-10$; odds ratio, 0.34), biologically effective dose ($p = 1.01E-27$), and treatment with electron beam or Co-60 vs. other techniques ($p = 0.0014$; odds ratio, 0.72). Different radiobiological models calculated values of $\alpha/\beta = 1.12$ to 2.86 (mean, 2.08) and time (repopulation) correction factors for biologically effective dose from 0.98 to 2.13 Gy per day (mean, 1.34) starting 10 days after surgery. Different models (with $\alpha/\beta = 2.08$) predicted that doses needed for 90% and 95% control with 3 fractions of postoperative electron beam were 16.0 to 16.2 Gy and 18.3 to 19.2 Gy, respectively, in less than 10 days for earlobe keloids and 21.5 to 22.2 Gy and 23.4 to 24.8 Gy, respectively, in less than 10 days for other sites.	M
52	Garcia-Barros M, Paris F, Cordon-Cardo C, et al. Tumor response to radiotherapy regulated by endothelial cell apoptosis. Science. May 16 2003;300(5622):1155-9. doi:10.1126/science.1082504	Preclinical	MCA/129 fibrosarcomas and B16F1 melanomas grown in apoptosis-resistant acid sphingomyelinase (asmase)-deficient or Bax-deficient mice were used	To investigate the hypothesis that tumor response to radiation is determined not only by tumor cell phenotype but also by microvascular sensitivity.	MCA/129 fibrosarcomas and B16F1 melanomas grown in apoptosis-resistant acid sphingomyelinase (asmase)-deficient or Bax-deficient mice displayed markedly reduced baseline microvascular endothelial apoptosis and grew 200 to 400% faster than tumors on wild-type microvasculature. Thus, endothelial apoptosis is a homeostatic factor regulating angiogenesis-dependent tumor growth. Moreover, these tumors	4

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					exhibited reduced endothelial apoptosis upon irradiation and, unlike tumors in wild-type mice, they were resistant to single-dose radiation up to 20 grays (Gy). These studies indicate that microvascular damage regulates tumor cell response to radiation at the clinically relevant dose range.	
53	Lee SY, Park J. Postoperative electron beam radiotherapy for keloids: treatment outcome and factors associated with occurrence and recurrence. <i>Ann Dermatol.</i> Feb 2015;27(1):53-8. doi:10.5021/ad.2015.27.1.53	Retrospective	Of these 37 lesions, 22 were located in the ear lobe, 6 in the helix of the auricle, 4 on the shoulder, 3 on the chest wall, and 2 on the abdomen. Causative factors were piercings (n=24), trauma (n=5), previous surgical lesions or bacillus Calmette-Guerin vaccination lesions (n=3) and acne (n=2). Radiation therapy was initiated within 24 h in 24 lesions, between 24 and 72 h in 6 lesions, and after more than 72 h in 7 lesions.	To determine the appropriate time for initiating postoperative radiotherapy and to analyze factors associated with the occurrence and recurrence of keloids.	Seven lesions recurred, including 5 recurrences in high stretch-tension regions (p=0.010). Initial treatments were administered within 24 h in 1 lesion and more than 72 h after surgical excision in 6 lesions (p<0.0001). In the 19 patients with family histories, maternal and paternal genetic predispositions were present in 14 and 5 patients, respectively (p=0.033).	3
54	Caccialanza M, Piccinno R, Schiera A. Postoperative radiotherapy of keloids: a twenty-year experience. <i>Eur J Dermatol.</i> Jan-Feb 2002;12(1):58-62.	Retrospective	A retrospective study on 156 keloids, histologically ascertained, treated by means of orthovoltage radiotherapy in the last twenty years. The total doses administered ranged from 15 to 40 Gy. The radiotherapy started within 7 days from surgery in 127 lesions (81.4%), and within 3 weeks in the remaining 29 (18.6%). Surgical methods to minimize tension at wound sites were adopted.	To evaluate the effectiveness and safety of postoperative radiotherapy	he follow-up ranged from 6 to 216 months. After irradiation a complete remission was obtained in 141 lesions (90.4%) and a partial response in 15 lesions (9.6%). The five-year relapse-free rate was 86.68%. Cosmetic results were evaluated as good or acceptable in 82.73% of the lesions. Afterwards, 17 lesions (10.89%) have relapsed. No stochastic or non stochastic effects have been observed.	3
55	Levy DS, Salter MM, Roth RE. Postoperative irradiation in the prevention of keloids. <i>AJR Am J Roentgenol.</i> Sep 1976;127(3):509-10. doi:10.2214/ajr.127.3.509	Retrospective	35 patients with hypertrophic scars or keloids	To present clinical manifestation of keloids, physiology of wound healing, pathophysiology of keloid formation, and the radiation technique utilized in the treatment of keloids	Low dose superficial x-irradiation to the incisional site after surgical excision of a keloid prevented keloid or hypertrophic scar formation in 31 of 35 patients evaluated (88%). This study shows that the method is well tolerated, easily administered, and efficient in inhibiting recurrence of keloid or hypertrophic scar formation.	3

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59	Ogawa R, Akaishi S, Kuribayashi S, Miyashita T. Keloids and Hypertrophic Scars Can Now Be Cured Completely: Recent Progress in Our Understanding of the Pathogenesis of Keloids and Hypertrophic Scars and the Most Promising Current Therapeutic Strategy. J Nippon Med Shc. 2016;83(2):46-53. doi:10.1272/jnms.83.46.	Review	Review	To review pathogenesis and treatment strategies for keloids	Keloids and hypertrophic scars are fibroproliferative disorders of the skin that are caused by abnormal healing of injured or irritated skin. It is possible that they are both manifestations of the same fibroproliferative skin disorder and just differ in terms of the intensity and duration of inflammation. These features may in turn be influenced by genetic, systemic, and local risk factors. Genetic factors may include single nucleotide polymorphisms, while systemic factors may include hypertension, pregnancy, hormones, and cytokines. The most important local factor is tension on the scar. Over the past 10 years, our understanding of the pathogenesis of keloids and hypertrophic scars has improved markedly. As a result, these previously intractable scars are now regarded as being treatable. There are many therapeutic options, including surgery, radiation, corticosteroids, 5-fluorouracil, cryotherapy, laser therapy, anti-allergy agents, anti-inflammatory agents, bleaching creams and make-up therapies. However, at present, we believe that the following combination of three therapies most reliably achieves a complete cure: surgery, followed by radiation and the use of steroid tape/plaster.	4
60	Hsueh WT, Hung KS, Chen YC, et al. Adjuvant Radiotherapy After Keloid Excision: Preliminary Experience in Taiwan. Ann Plast Surg. Jan 2019;82(1S Suppl 1):S39-S44. doi:10.1097/SAP.0000000000001728	Retrospective	A retrospective chart review of the included consecutive keloid patients receiving surgical excision and radiotherapy was performed from 2013 to 2016 in a single institute. The reported risk factors were collected to investigate according to the outcome analysis. The Vancouver Scar Scale and the Japan Scar Workshop (JSW) Scar Scale were used to evaluate the correlation with keloid recurrence.	To review the results of adjuvant RT following keloid excision in Taiwanese patients	In this series, the overall recurrence rate was 32%, reported with an average follow-up of 28 months. Independent risk factors varied according to the different outcome variables. Only JSW classification score independently predicted the risk of keloid recurrence (odds ratio, 1.305; P = 0.02). Both the Vancouver Scar Scale and the JSW system showed a good correlation with keloid recurrence (correlation efficiency, 0.529 and 0.54; P = 0.0437 and 0.0165, respectively).	3
61	Bhattacharya N, Bhattacharya K, Chandran TC. Treatment of Keloids with Surgery and Immediate Postoperative Radiotherapy: Knowledge Gained Over 17 Years. Indian J Plast Surg. Jun 2023;56(3):251-259. doi:10.1055/s-0043-1761599	Retrospective	Since 2004, 120 patients presenting with keloidal scars were seen by the author. Out of them, 50 were managed with surgery followed by HDR brachytherapy/electron beam	To confirm the effectiveness of adjuvant RT after excision of keloids	Three patients developed a nodule in the scar, which was deemed a recurrence, making an incidence of 6%. There was no major problem after immediate postoperative radiotherapy. Five patients had delayed healing at 2 weeks and a	3

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			radiotherapy delivering 2000 rads to the scar within 24 hours of surgery. Patients were followed up for at least 18 months to assess the scar status and the recurrence of keloids. Recurrence was defined as the appearance of a nodule or an obvious return of the keloid within 1 year of treatment.		hypertrophic scar was noted in five patients at 4 weeks that settled with conservative measures.	
62	Shen J, Lian X, Sun Y, et al. Hypofractionated electron-beam radiation therapy for keloids: retrospective study of 568 cases with 834 lesions. J Radiat Res. Sep 2015;56(5):811-7. doi:10.1093/jrr/rrv031	Retrospective	From February 1998 to January 2012, 568 patients with a total of 834 keloids underwent radiotherapy: 826 lesions with postoperative radiotherapy, and 36 with skin-grafting. Lesion size was >5 cm in 335 keloids. An electron-beam of 6 or 7 MeV was used, with a total dose of 18 Gy (two fractions with a 1-week interval) covering the lesion with a 1-cm margin. The time between surgery and radiotherapy was 24-48 h. Skin-grafted patients underwent radiotherapy 10-15 days after the operation.	To analyze the outcomes of hypofractionated high-energy electron beam radiotherapy for the treatment of keloids.	The median follow-up was 40 months (range: 12-160 months). The local control rate was 88.25% (736/834). The relapse rate was 9.59% (80/834), and the time to relapse was 6-28 months (median: 12 months). Univariate analyses showed that gender, age, keloid size, keloid site, skin grafting, and operation-to-irradiation interval influenced the local control rate. Multivariate analysis showed that the relapse rate was correlated with gender (P = 0.048), age (P < 0.01), operation-to-irradiation interval (P < 0.01), keloid site (P < 0.01), surgical method (P = 0.04) and keloid size (P < 0.02). Adverse effects were observed in 9.83% (82/834). No radiation-induced cancers were observed. Hypofractionated high-energy electron beam radiotherapy for keloids yielded excellent outcomes, especially in cases without skin grafting.	3
63	Kim J, Lee SH. Therapeutic results and safety of postoperative radiotherapy for keloid after repeated Cesarean section in immediate postpartum period. Radiat Oncol J. Jun 2012;30(2):49-52. doi:10.3857/roj.2012.30.2.49	Retrospective	A total of 26 postpartum patients with confirmed keloids resulting from previous Cesarean sections received either 12 or 15 Gy radiotherapy. The radiotherapy was divided into three 6 MeV electron beam fractions administered during the postpartum period immediately following the final Cesarean section. To evaluate ovarian safety, designated doses of radiation were estimated at the calculated depth of the ovaries using a solid plate phantom and an ionization chamber with the same lead cutout as was used for the treatment of Cesarean section	To evaluate the effectiveness and safety of postoperative radiotherapy for the treatment of keloid scars administered immediately after Cesarean section.	In total, the control rate was 77% (20 patients), while six (23%) developed focally elevated keloids (ranging from 0.5 to 2 cm in length) in the middle of the primary abdominal scar. Five patients experienced mild hyperpigmentation. Nonetheless, most patients (96%) were satisfied with the treatment results. The estimated percentage of the applied radiation doses that reached the calculated depth of the ovaries ranged from 0.0033% to 0.0062%.	3

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			operative scars and a tissue equivalent bolus.			
64	Ogawa R, Tosa M, Dohi T, Akaishi S, Kuribayashi S. Surgical excision and postoperative radiotherapy for keloids. Scars Burn Heal. Jan-Dec 2019;5:2059513119891113. doi:10.1177/2059513119891113	Retrospective	Customized protocol so that body sites that are highly prone to recurrence (e.g. the anterior chest) receive higher doses while low recurrence sites like the earlobe receive a much smaller dose. 18 Gy/3 fr/3 days to high-recurrence sites, 8 Gy/1 fr/1 day to earlobes and 15 Gy/2 fr/2 days to other body sites.	To report the results of customized adjuvant radiation protocols depending on keloid body site	The maximal biologically effective dose (BED) for keloids is 30 Gy (using an estimated α / β ratio of 10); increasing the dose has no further benefits and elevates side effects. The overall keloid recurrence rate is 9% reported in this study.	3
65	Han SH, Ha B, Chang CH, Park TH. Efficacy of Immediate Postoperative Single Fractional 10 Gy Radiotherapy for Earlobe Keloids. J Craniofac Surg. Feb 12 2024;doi:10.1097/SCS.00000000000010002	Retrospective	The authors retrospectively evaluated 48 patients with 71 earlobe keloids treated with complete surgical excision followed by single-fractional 10 Gy radiotherapy within 24 hours from May 2021 to December 2022. The outcome was reported with a recurrence-free rate and side effects.	To present a single institution experience treating earlobe keloids through complete surgical excision followed by immediate postoperative single fraction 10 Gy radiation therapy either on the same day or the next day.	The mean follow-up period was 20.8 months. All patients tolerated the treatments well. The overall recurrence-free rate was 100%. There were only 2 grade III radiation dermatitis. There were no reports of second malignancies or severe complications.	3
66	Hwang NH, Lee NK, Chae JH, Park SH, Yoon ES. The Efficacy of CT-Based Conformal Electron Beam Radiation Therapy After Keloid Excision. Dermatol Surg. Apr 1 2022;48(4):435-440. doi:10.1097/DSS.0000000000003398	Prospective nonrandomized	Medical records of patients with keloids, who were treated with postoperative electron beam RT between January 2015 and December 2020, were reviewed. A total of 85 consecutive patients with 136 keloids were included in this study. Subjective cosmetic outcomes were scored by each patient using a 5-point Likert scale survey.	To report treatment and cosmetic outcomes following keloid excision and RT by the patient's self-assessment survey.	The median follow-up time was 29.0 months (range, 12.1-77.9 months), and local recurrence was observed in 10 lesions (7.4%). The recurrence rate of keloids occurring in the ear was 5.4%, whereas the recurrence rate of keloids occurring at other body sites was 11.4%. Among the patients who responded to the questionnaire about the cosmetic outcome, 70.2% of patients declared being either very satisfied (44.7%) or satisfied (25.5%).	2
67	Wen P, Wang T, Zhou Y, Yu Y, Wu C. A retrospective study of hypofractionated radiotherapy for keloids in 100 cases. Sci Rep. Feb 11 2021;11(1):3598. doi:10.1038/s41598-021-83255-4	Retrospective	We retrospectively analysed the medical records of keloid patients receiving auxiliary postoperative radiotherapy (PORT) treatment from 2009 to 2019. The patients were treated with the hypofractionation method of 20 Gy in 5 fractions. We compared	To assess the efficacy and safety of a specific treatment regimen (20 Gy in 5 fractions) in keloid patients.	In this study, the overall local control rate of keloid lesions was 84.8%. After multivariate analyses (primary keloid or not, family history, interval from surgery to irradiation and site), our research showed that primary keloid, site and interval from surgery to irradiation were significantly related to recurrence. Acute radiation injury and late	3

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			the local control rate and complications, using the chi-square test and logistic regression analyses. After screening, we identified 100 keloid patients in this study, with a median follow-up of 59 months.		radiation injury accounted for 3% (erythema) and 1% (skin sclerosis) of the total cases, respectively.	
68	Rishi KS, Sarkar N, Kesari P, et al. Single Institution Experience of Postoperative Electron Beam Radiation Therapy in the Treatment of Keloids. Adv Radiat Oncol. Mar-Apr 2021;6(2):100596. doi:10.1016/j.adro.2020.10.009	Retrospective	Twenty-two patients with 40 keloids treated postoperatively with electron beam radiation at our institution from 2014 to 2019 were analyzed retrospectively. Electron beam radiation was used for treatment in all cases, and radiation was initiated within 24 hours of surgery. A dose of 20 Gy in 5 fractions was delivered to the postoperative scar in 95% of the sites, and 8 Gy to 10 Gy in a single fraction was delivered to the remaining 5%. The patients were followed up, and recurrences were documented.	To report outcomes for patients who received postoperative electron beam RT following keloid excision	At a mean follow-up of 35 months (range, 7-66 months), local control and cosmesis were achieved in 90% (36 of 40) of the treated sites with electron beam radiation therapy delivered at a dose of 20 Gy in 5 fractions. All recurrent keloids were located on the anterior chest wall over the sternum. There was no difference in outcome based on age, sex, or keloid length.	3
69	Wang Y, Ma J, Zhang Z, Shen H. Combined surgical excision and electron external beam radiation improves the treatment of keloids: A descriptive study. Dermatol Ther. 2020 Jul;33(4):e13494. doi: 10.1111/dth.13494.	Prospective cohort	A total of 58 patients aged between 21 and 76 years received surgical incision of keloid and immediate postoperation low-dose radiotherapy. All patient follow-ups were performed at the out-patient department. Any sign of a keloid at the incision site was defined as treatment failure or keloid recurrence, regardless of the size.	To improve the surgical techniques that reduce local tension after surgical excision of keloids as well as applying adjuvant radiotherapy to suppress scar formation.	At a median follow-up of 22 months, the overall recurrence for all lesions was 8.6%, which is improved compared with previous study. In addition, all incisions performed during surgeries were healed and no signs of necrosis or the development of ulcers was observed.	2
70	Liu CL, Yuan ZY. Retrospective study of immediate postoperative electron radiotherapy for therapy-resistant earlobe keloids. Arch Dermatol Res. Aug 2019;311(6):469-475. doi:10.1007/s00403-019-01922-z	Retrospective	From 2011 to 2017, three-fraction electron radiotherapy with single dose of 5 Gy was given postoperatively to 23 patients with 30 keloids in our hospital. The first fraction of adjuvant radiotherapy was administered within 2 h of surgery, and the other two sessions were completed within the next day or two.	To analyze the efficacy and safety of immediate three-fraction electron radiotherapy after operation for resistant earlobe keloids.	Five (16.7%) primary keloids and 25 (83.3%) recurrent keloids were examined in this study. The primary endpoint was the local control rate, which was 86.7% after a median follow-up of 26 months (14-93 months). Secondary endpoints were acute and late procedure-related complications, and no severe complications were observed after combination therapy.	3

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71	Sruthi K, Chelakkot PG, Madhavan R, Nair RR, Dinesh M. Single-fraction radiation: A promising adjuvant therapy to prevent keloid recurrence. J Cancer Res Ther. Oct-Dec 2018;14(6):1251-1255. doi:10.4103/jcrt.JCRT_20_17	Retrospective	Details of patients treated for keloids using external beam radiation therapy from January 2011 to December 2016 were retrieved from electronic medical records and radiation therapy charts and analyzed.	To analyze the efficacy of single-fraction high-dose adjuvant radiotherapy to prevent keloid recurrence.	Thirty-seven keloid lesions in thirty patients were analyzed. Keloids received radiation within 24-72 h postsurgery using 6 MeV electron beam. 45.9% of keloids were in the chest wall. Dose ranged between 5 Gy and 12 Gy in 1-3 fractions. Eight Gy was used in 78.4%. The single fraction was preferred in 91.9%. Good cosmesis was achieved in all except three who had wound dehiscence. Median follow-up was 32.67 months. 16.2% had recurrence. Median time to recur was 13.6 months, and median recurrence-free interval 21.23 months. Among those who received 8 Gy single fraction, 73.4% remained recurrence-free at 5 years.	3
72	Renz P, Hasan S, Gresswell S, Hajjar RT, Trombetta M, Fontanesi J. Dose Effect in Adjuvant Radiation Therapy for the Treatment of Resected Keloids. Int J Radiat Oncol Biol Phys. Sep 1 2018;102(1):149-154. doi:10.1016/j.ijrobp.2018.05.027	Retrospective	A retrospective review of 124 patients with 250 keloid lesions treated with postoperative radiation therapy was analyzed. In this institutional review board-approved study, 125 keloids were treated to 20 Gy in 5 fractions and 125 keloids were treated to 12 to 16 Gy in 3 to 4 fractions. Local failure was defined as redevelopment of any clinically apparent keloid at the treated site. The median age was 34 years (14-84 years). Keloids were located on the ear (34%), neck/shoulder (19%), abdomen (13%), chest (10%), face (9%), breast (7%), extremities (4%), and back (3%). Median keloid size was 4 cm (0.5-20 cm).	To present our results of postoperative radiation therapy for keloids with various dose regimens.	At a median follow-up of 40 months, the recurrence rate for all lesions was 5.6%. Lesions treated to 20 Gy had a recurrence rate of 1.6% compared with 9.6% with <20 Gy and an odds ratio of 0.16 (P = .02). Upon univariate and multivariate analysis there were no differences in recurrence rate with respect to location, race, gender, age, previously treated lesions, and presence of multiple keloids. The lone predictor for improved control rate was the dose of 20 Gy in 5 fractions compared with less than that. Control rate for lesions treated to a biologically equivalent dose2 of 35 to 36 Gy2, 48 to 52.5 Gy2, and 60 to 72 Gy2 were 10% (P = .007), 8.9% (P = .16), and 1.6% (P = .02), respectively.	3
73	Khalid FA, Farooq UK, Saleem M, et al. The efficacy of excision followed by intralesional 5-fluorouracil and triamcinolone acetonide versus excision followed by radiotherapy in the treatment of ear keloids: A randomized control trial. Burns. Sep 2018;44(6):1489-1495. doi:10.1016/j.burns.2018.02.017	Prospective randomized controlled	60 patients presented in the outpatient department fulfilling the inclusion criteria were selected and randomly assigned in two groups with the help of the random number table. Patients in group A had excision followed by intralesional 5-FU/TAC injections while patients of group B had excision followed by radiotherapy.	To to compare the efficacy of post-excision intralesional 5-fluorouracil/ triamcinolone acetonide (5-FU/TAC) and post-excision radiotherapy in the treatment of ear keloids.	60 patients completed the study, with 30 patients in each group. 7 patients (23.34%) in Group-A and 9 patients (30%) in Group-B were males while 23 patients (76.67%) in Group-A and 21 patients (70%) in Group-B were females i.e. male to female ratio is 1:2.75. Mean age was 31.8+6.48years. The comparison of frequency of efficacy in both groups showed that 73.33% (n=22) in Group-A and 43.33% (n=13) in Group-B had efficacy, p value was	1

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			Patients were assessed at 6 months after completion of treatment for efficacy (no recurrence within 6 months of treatment).		calculated as 0.01, showing a significant statistical difference.	
74	Hoang D, Reznik R, Orgel M, Li Q, Mirhadi A, Kulber DA. Surgical Excision and Adjuvant Brachytherapy vs External Beam Radiation for the Effective Treatment of Keloids: 10-Year Institutional Retrospective Analysis. <i>Aesthet Surg J</i> . Feb 2017;37(2):212-225. doi:10.1093/asj/sjw124	Case-controlled	One-hundred and twenty-eight patients, with 264 keloid lesions, were treated by excision alone (n = 28), post-excision EBRT (n = 197), or post-excision HDR brachytherapy (n = 39). Patient and keloid recurrence data were analyzed using mixed effect Cox regression modeling with a statistical threshold of P < .05.	To perform a case-control retrospective study (2004-2014) of keloid recurrence rates and complications between post-excision EBRT and HDR brachytherapy.	Fifty-four percent of keloids recurred after surgical excision alone (9-month median follow up); 19% of keloids recurred with post-excision EBRT (42-month median follow up); 23% of keloids recurred with post-excision brachytherapy (12-month median follow up). Adjuvant EBRT and brachytherapy each showed significant control of keloid recurrence compared to excision alone (P < .01). EBRT significantly delayed the time of keloid recurrence over brachytherapy by a mean difference of 2.5 years (P < .01).	2
75	Carvajal CC, Ibarra CM, Arbulo DL, Russo MN, Sole CP. Postoperative radiotherapy in the management of keloids. <i>Ecancermedicallscience</i> . 2016;10:690. doi:10.3332/ecancer.2016.690	Retrospective	Retrospective analysis of resected keloids in patients referred to a Chilean radiation oncology centre between 2006 and 2013. Local recurrence was defined as new tissue growth on the surgical scar margin.	To assess keloid recurrence when treated with surgery and adjuvant radiotherapy.	Around 103 keloids were analysed in 63 patients treated with 15 Gy in three fraction radiotherapy which was initiated on the same day as the surgery (75% of cases). The median keloid diameter was 6 cm; the most common site was thoracic (22%); the most common cause was prior surgery (35%); 37% caused symptoms, and several (47%) had received prior treatment with corticosteroids (32%), or surgery (30%). The median follow-up was three years, and 94% of recurrences occurred during the first year following treatment. Uni and multivariate analyses showed that an absence of symptoms was a protective factor for recurrence (OR: 0.24), while the time interval from onset to treatment with surgery plus radiotherapy >4.2 years was a risk factor (OR: 2.23). The first year recurrence rate was 32% and stabilised at 32% by the second year with no recurrences after 15 months.	3
76	Song C, Wu HG, Chang H, Kim IH, Ha SW. Adjuvant single-fraction radiotherapy is safe and effective for intractable keloids. <i>J Radiat Res</i> . Sep 2014;55(5):912-6. doi:10.1093/jrr/rru025	Prospective nonrandomized	A total of 12 patients with 16 keloid lesions were treated from January 2010 to January 2013 in our department. A 10-Gy dose of electron irradiation was given within 72 h of the surgical excision.	To report a single institution experience using high-dose single-fraction radiotherapy after keloid excision	The mean follow-up period was 20 months. Treatments were well tolerated, and there was no recurrence in any of the patients. Severe adverse effects were not observed.	2
77	Sakamoto T, Oya N, Nagata Y, Hiraoka M. The outcome and the adverse effect of postoperative radiotherapy for keloids: A prospective study with a total dose of 20	Prospective nonrandomized	From January 1995 to May 2003, 235 keloids in 181 patients (62 male and 119 female, median age 33 years old) received	To report the outcome and the adverse effects in patients with	All patients completed the scheduled treatment. 27 out of 235 keloid scars (11%) relapsed. A univariate and a multivariate analysis with various prognostic factors showed that the relapse rate	2

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	Gy. International Journal of Radiation Oncology Biology Physics. 2004;60(1):s549. Doi: 10.1016/j.ijrobp.2004.07.521		postoperative radiotherapy with a total dose of 20 Gy in 5 fractions over 9 to 14 days. Soft X-rays (55 or 100 kVp) or electron beams (5 or 7 MeV) were used. The 90% isodose target area included the entire postoperative scar and any suture/puncture hole with a margin of 3–5 mm around the lesion. Non-target area was shielded by individually cut-out 1–2 mm lead sheet. The size and height of keloid, cosmetic status, symptoms, and adverse effects were prospectively evaluated every several months after radiotherapy. The median follow-up period was 21.4 months (range 6–81 months).	postoperative keloids treated with 20 Gy.	was significantly correlated with the site of keloids. The relapse rate was 15% for the keloid scars under high stretch tension (e.g. anterior chest wall, shoulder, and suprapubis), while 0% for those without high tension (e.g. face, neck, earlobes, hip, and lower limbs). Cosmetic status was judged to be excellent in 48 lesions (20%), good in 152 lesions (65%), and fair in 24 lesions (10%). Among 191 lesions, which caused itching and/or pain before treatment, symptomatic relief was achieved in 177 lesions (93%). No severe (grade 3 or above) treatment-related toxicity was observed. The incidence of hyperpigmentation and/or telangiectasis was 10%.	
78	Chen F, Kuo YR, Huang CJ, Tang JY, Chiang CH, Huang MY. Lesion Site Is the Key Prognostic Factor for Keloid Patients Receiving Surgery With Adjuvant Radiotherapy. Ann Plast Surg. Dec 1 2022;89(6):626-630. doi:10.1097/SAP.0000000000003315	Retrospective	All patients received radiation dose with 15 Gy, with their first radiotherapy within 24 hours after surgical excision. The end points were recurrence rate and local recurrence-free interval (LRFI), defined clinically as palpable gross tumor over the treatment site and duration from the last day of radiotherapy to disease recurrence.	To review outcomes of keloid patients receiving surgery and adjuvant radiotherapy in Kaohsiung Medical University Hospital.	From May 2017 to July 2020, 32 patients with 40 keloid lesions were included. The mean age for these patients was 37.6 years, and the median follow-up time was 15.3 months. The overall recurrence rate was 52.5%, and the median LRFI was 9.7 months. Recurrence rates for males and females were 46.7% and 56% (P = 0.567), respectively; for head and ear, chest, shoulder and upper extremities, and abdomen and back were 12.5%, 61.5%, 63.6%, and 62.5% (P = 0.093); for lesions over 20 cm ² and below 20 cm ² were 62.5% and 50% (P = 0.527); and for megavoltage electron beam and kilovoltage photon beam were 56.7% and 40% (P = 0.361), respectively. Patients were further classified into 2 groups by lesion sites, which showed lower recurrence rate (P = 0.011) and longer LRFI (P = 0.028) with lesions over the head and ear than other sites.	3
79	Katano A, Minamitani M, Yamashita H. Risk factors for local recurrence of keloids and hypertrophic scars after postoperative electron beam radiotherapy. J Cancer Res Ther. Jan 1 2024;20(1):163-166. doi:10.4103/jcrt.jcrt_1861_22	Retrospective	Patients with keloid or hypertrophic scars with at least one lesion and who underwent postoperative electron beam radiotherapy at our institution from June 2013 to March 2022 were included in the study, while	To identify the risk factors for recurrence after postoperative electron beam radiotherapy.	A retrospective analysis was performed on 94 lesions in 81 patients. Exactly two years after the treatment, the actuarial local control rate was 86.4%. The chest wall, shoulder, and suprapubic area were identified as high-risk recurrence sites. Compared to other body sites, these sites had significantly lower local control rates (two-year	3

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			patients with a follow-up period of fewer than three months were excluded.		local control rates: 75.5% vs. 95.2%, $P = 0.005$). After multivariate analysis, treatment site ($P = 0.014$), male gender ($P = 0.019$), and younger age ($P = 0.029$) were revealed to be statistically significant risk factors for local recurrence. Risk factors for keloid recurrence after postoperative electron beam radiotherapy were therefore identified.	
80	Liu C. Risk factors for recurrence after keloid surgery with electron radiotherapy. <i>Medicine</i> (Baltimore). Oct 27 2023;102(43):e35683. doi:10.1097/MD.00000000000035683	Retrospective	The clinical data of 82 patients treated at our institution from January 2015 to October 2019 were collected. The data included the general condition of the patients, clinical characteristics of the keloids, treatment plan, local control, and treatment side effects. A total of 82 patients (129 keloids) were included. The study included 23 men (28%) and 59 females (72%). The median patient age was 32 years (range, 18-67 years).	To investigate the effect of postoperative electron radiotherapy (RT) on local control for keloids and to identify risk factors for recurrence.	Twenty-six recurrences were observed, and the 1-, 3-, and 5-year local control rates were 93%, 81%, and 73%, respectively. Univariate analysis revealed that age ($P = .03$), hypertension ($P = .04$), scar shape ($P < .001$), primary site ($P = .02$), maximum lesion diameter ($P < .001$), pain and itching ($P = .005$), local tension ($P = .005$), and infection ($P < .001$) were risk factors for local recurrence. Multivariable analysis revealed that maximum lesion diameter ($P < .001$), infection ($P < .001$), interval between surgery and RT ($P = .02$), and previous treatment ($P = .02$) were independent risk factors.	3
81	Yang X, Shao Y, Yu W, et al. A Novel Radiotherapy Approach for Keloids with Intrabeam. <i>Biomed Res Int</i> . 2019;2019:4693528. doi:10.1155/2019/4693528	Prospective nonrandomized	Fourteen patients who have undergone Intrabeam radiotherapy for a total of 15 sites of keloids were followed up. Twelve cases were first onset and the other two had recurrent diseases. Thirteen patients underwent surgical resection of keloids before radiotherapy. One relapsing patient received only 2 rounds of radiation therapy as she could not be reoperated. Radiotherapy was divided into 2 sessions on days 0 and 3 after surgery. The dose was 4 or 5 Gy each time for 3 min 14 s to 12 min 1 s. In addition, we compared our data to the recurrence of keloids in fourteen patients who had previously been exposed to electron beam using conventional accelerators.	To evaluate Intrabeam photon radiotherapy in the management of keloids.	We analyzed the treatment for adverse reactions and recurrence. In the Intrabeam group, one patient developed superficial skin ulcers a month after treatment. No one experienced wound rupture, bleeding, infection, skin contractures, or obvious hyperpigmentation. None of the fourteen cases showed any recurrence so far after on median 22.5 months of follow-up. Five patients in the electron beam group relapsed 3 to 10 months after treatment.	2

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82	Speranza G, Sultanem K, Muanza T. Descriptive study of patients receiving excision and radiotherapy for keloids. Int J Radiat Oncol Biol Phys. Aug 1 2008;71(5):1465-9. doi:10.1016/j.ijrobp.2007.12.015	Retrospective	This was a retrospective study. Patients who received radiotherapy between July 1994 and January 2004 after keloid excision were identified. A questionnaire was mailed regarding sociodemographic factors, early and late radiation toxicities, the need for additional therapy, and satisfaction level. All patients had received a total of 15 Gy in three daily 5-Gy fractions. Treatment started within 24 h after surgery and was delivered on a Siemens orthovoltage machine. The data were analyzed using the STATA statistical package.	To review and describe our institution's outcomes in patients treated with external beam radiotherapy after keloid excision.	A total of 234 patients were approached. The response rate was 41%, and 75% were female. The mean age was 36.5 years (range, 16-69 years). The patients were mainly of European (53.1%) or African (19.8%) descent. For early toxicity outcomes, 54.2% reported skin redness and 24% reported skin peeling. For late toxicity outcomes, 27% reported telangiectasia and 62% reported permanent skin color changes. No association was found with gender, skin color, or age for the late toxicity outcomes. Of the patients responding, 14.6% required adjuvant treatment. On a visual scale of 1-10 for the satisfaction level, 60% reported a satisfaction level of > or =8. Telangiectasia was the most significant predictor of a low satisfaction level (< or =3, p < 0.005).	3
83	Ponteriero A, Potami A, Iati G, et al. Post-operative radiotherapy of keloids. A 10-years experience of kilovoltage irradiation. International Journal of Radiation Research. 2015;13(3):201-204. doi:10.7508/ijrr.2015.03.001	Retrospective	Sixty-two patients with keloids were treated postoperatively using orthovoltage irradiation. The total dose delivered was 12 Gy in three consecutive days, 4Gy per fraction. Treatment started 24 h after surgery. The median follow-up was 44.5 months.	To evaluate the role of post-operative superficial orthovoltage radiotherapy in the management of keloids.	Grade 1 erythema was observed in 48% of patients (30/62); 20/62 patients (32%) showed telangiectasia and altered skin pigmentation as late toxicities. In 10/62 (16%) a clinical relapse was observed.	3
84	Mohammadi AA, Mohammadian Panah M, Pakyari MR, et al. Surgical excision followed by low dose rate radiotherapy in the management of resistant keloids. World J Plast Surg. Jun 2013;2(2):81-6. PMID: 25489509	Retrospective	Between January 2008 and April 2011, seventeen patients (mostly burn patients) with 26 keloids went through surgical resection followed by radiotherapy. A total dose of 15 Gy in 5 fractions was administered to the areas of scar formation.	To determine the effectiveness of low dose rate radiotherapy following surgical excision in treating resistant keloids.	All patients were followed for at least 11 months (mostly for 20 months). No recurrence occurred. There was no complication or adverse effect.	3
85	Ramelyte E, Welti M, Gardin F, Maul JT, Dummer R, Imhof L. Post-Excision Soft X-Ray Radiotherapy for Keloids: Experience in a Tertiary Referral Center. Dermatology. 2024;240(4):572-580. doi:10.1159/000539782	Retrospective	We reviewed retrospective data of all patients, treated with adjuvant post-excision soft X-ray radiotherapy with 12 Gy in 6 sessions at the tertiary referral center, Department of Dermatology, University Hospital Zurich, Switzerland, between 2005 and 2018. We analyzed individual keloids as separate cases. Successful treatment was defined	To evaluate the keloid recurrence rate after post-excision soft X-ray radiotherapy and the associated factors.	Of the 200 identified patients, 90 met the inclusion criteria and were included in the final analysis. In 90 patients, 104 cases of treated keloids were analyzed. Keloids were mainly located on the trunk (49%) and were mostly caused by previous surgery (52.2%). 50% of the keloids did not relapse within 2 years after therapy. A significant factor leading to recurrence was the presence of previous therapy, with prior topical therapies, such as steroid injections or 5-fluorouracil, leading to most relapses. 69.2% of keloid cases who relapsed were	3

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			as no sign of recurrence within 2 years.		pretreated. Soft X-ray radiotherapy was well tolerated, with posttreatment hyperpigmentation noted in 34% of patients, particularly in patients with non-Caucasian origin (61.3%).	
86	Tsai SL, Tsai YC, Weng YT, Huang WY, Wang CH. Keloid Excision With Primary Closure Combined With Superficial Radiation Therapy (SRT-100). <i>Ann Plast Surg.</i> Mar 1 2025;94(3S Suppl 1):S18-S23. doi:10.1097/SAP.0000000000004187	Retrospective	We retrospectively collected data from patients who underwent keloid excision with postoperative radiotherapy at our hospital. All patients underwent keloid excision and primary wound closure without Z-plasty or a local flap. Subsequently, patients underwent 2 or 3 fractions of superficial radiation therapy (SRT) on postoperative days 0, 1, and 2 (in 3 fractions). We collected data on the patients' preoperative Vancouver Scar Scale (VSS), 2-month follow-up VSS score, recurrence, and side effects.	To report data on Taiwanese patients who underwent keloid excision with simple primary closure and superficial radiation therapy.	In total, 16 keloids in 12 patients were treated with excision, primary closure, and superficial radiation therapy. The mean preoperative VSS was 8.69 ± 1.79 , whereas the mean 2-month postoperative VSS was 3.56 ± 0.70 . Most of the keloids were followed up for more than 6 months. No keloid recurrence was observed. A side effect of radiotherapy is hyperpigmentation of the skin surrounding the surgical scar.	3
87	Jones ME, Ganzer CA, Bennett D, Finizio A. Surgical Excision of Keloids Followed by In-office Superficial Radiation Therapy: Prospective Study Examining Clinical Outcomes. <i>Plast Reconstr Surg Glob Open.</i> May 2019;7(5):e2212. doi:10.1097/GOX.0000000000002212	Prospective nonrandomized	Participants for this study were recruited from June 2016 through February 2017 with 48 subjects enrolled and completed this study. All keloids were surgically resected and participants received 3 consecutive days of a customized dose of SRT, with a maximum cumulative dosage of 18 Gy. Patients were followed over the course of 12 months to monitor outcomes.	To evaluate the effectiveness of surgical excision followed by in-office superficial radiation therapy (SRT) as a method to improve keloid remission.	In this cohort, we found 39 (81%) to have achieved successful remission with 9 (19%) being classified as refractory. There were no adverse effects or medical complications reported as a part of this study.	2
88	Malaker K, Zaidi M, Franka MR. Treatment of earlobe keloids using the cobalt 60 teletherapy unit. <i>Ann Plast Surg.</i> Jun 2004;52(6):602-4. doi:10.1097/01.sap.0000095408.74866.f1	Prospective nonrandomized	Forty-seven earlobe keloids were given postoperative radiation using the smallest achievable half field Telecobalt technique.	To develop an easily accessible technique for the delivery of postoperative radiotherapy for the treatment of earlobe keloids.	41 (87.2%) of treated patients' postoperative scars remained free from recurrent keloid formation. Acute reactions were minimal and patient compliance was excellent.	2
89	Lin YF, Shueng PW, Roan TL, et al. Tomotherapy as an Alternative Irradiative Treatment for Complicated Keloids. <i>J Clin Med.</i> Nov 20 2020;9(11)doi:10.3390/jcm9113732	Prospective nonrandomized	From July 2018 to September 2018, 11 patients with 23 keloid lesions treated with HT were enrolled. Additionally, 11 patients with 20 lesions treated with	To investigate the treatment of complicated keloids with helical tomotherapy (HT)	The median follow-up period was 15 months. The local control rate was 91.3% and 80% in the HT group and the electron beam group, respectively. No acute adverse effects were observed in either group, but most patients exhibited pigmentation.	2

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			electron beam radiotherapy in the same period were enrolled. Patients in both groups were treated within 24 h after surgical excision of the keloid lesion with 13.5 Gy in three consecutive daily fractions.	and electron beam radiotherapy.	No radiation-induced cancer occurred in these patients up to the time of this report. Pain and pruritus improved for all patients and more obviously for three patients with complicated keloids treated with HT. The measured surface dose was 103.7-112.5% and 92.8-97.6% of the prescribed dose in the HT group and the electron beam group, respectively.	
90	Barragan VV, Garcia AIA, Garcia JF, Marin MJ, Vivas J, Rijo GJ. Perioperative interstitial high-dose-rate brachytherapy for keloids scar. J Contemp Brachytherapy. Feb 2022;14(1):29-34. doi:10.5114/jcb.2022.113547	Retrospective	A retrospective review of 61 keloids in 51 patients treated with perioperative interstitial HDR-BT was performed. Keloid lesions were treated with 12 Gy in 4 fractions within 48 hours. Time between surgery and brachytherapy was less than 90 minutes. Local failure was defined as recurrence of apparent keloid or symptoms in the same place. Median age of patients was 46 years (range, 20-89 years). Keloid scars were located on the chest (41%), ear lobe (21%), back (1.6%), extremities (11.5%), and mean keloid size was 6.3 cm.	To evaluate the results of keloids treated with perioperative interstitial high-dose-rate brachytherapy (HDR-BT).	With a median follow-up of 47.95 months (range, 1-96 months), the recurrence rate was 4.9%, all located on the chest. The multivariate analysis showed no statistically significant relationship between location, scar size, and previously treated lesions with the recurrence rate.	3
91	Anderson EM, David J, Phillips T, et al. Interstitial high-dose-rate brachytherapy in the treatment of keloids: Moving toward a volumetric approach. Brachytherapy. Jan-Feb 2021;20(1):185-188. doi:10.1016/j.brachy.2020.07.008	Retrospective	We retrospectively identified consecutive 14 patients who had a total of 20 keloids treated with interstitial high-dose-rate BT for keloids at our institution between 2004 and 2014. Keloids were treated with a single 8 Gy fraction prescribed to 5 mm beneath the scar within 36 h of surgery. Retrospectively, a 3-mm skin high-risk clinical target volume (HR-CTV) was contoured under the scar for volume-based dose calculations.	To investigate the dosimetry of a volume-based target definition for interstitial high-dose-rate BT treatment of keloids.	Mean (SD) HR-CTV was 3.91 cm ³ (3.1) and mean (SD) HR-CTV dose was 11.3 Gy (3.6). Mean D90 (SD) was 62.9% (25.8) and mean V100 (SD) was 56.5% (26.4). The mean V150 (SD), V200 (SD), and V300 (SD) were as follows: 37.6% (19.9), 25.1% (14.4), and 11.3% (6.5), respectively. No local failures were reported at 9 months median followup. There were no Grade 2 or higher late toxicities.	3
92	Hafkamp CJH, Lapid O, Davila Fajardo R, et al. Postoperative single-dose interstitial high-dose-rate brachytherapy in therapy-resistant keloids. Brachytherapy. Mar-Apr 2017;16(2):415-420. doi:10.1016/j.brachy.2016.12.009	Prospective nonrandomized	Patients treated by resection of the keloid plus a single dose of 13 Gy high-dose-rate brachytherapy were evaluated at least 1 year after treatment. Clinical response and cosmesis were assessed by a	To evaluate the recurrence rate and outcome after resection followed by a single-dose brachytherapy.	Only 24 of the 61 invited patients responded to participate with the study; 29 keloids were evaluated. The recurrence rate was 24.1% after a median followup of 53 months (19-95 months). Patients scored on average 24.3 for their total Patient and Observer Scar Assessment Scale score	2

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			plastic surgeon and by the patients using the Patient and Observer Scar Assessment Scale.		(range 6-52), whereas the observer scored on average 14.6 (range 6-42).	
93	Bijlard E, Verduijn GM, Harmeling JX, et al. Optimal High-Dose-Rate Brachytherapy Fractionation Scheme After Keloid Excision: A Retrospective Multicenter Comparison of Recurrence Rates and Complications. Int J Radiat Oncol Biol Phys. Mar 1 2018;100(3):679-686. doi:10.1016/j.ijrobp.2017.10.044	Retrospective	Patient cohorts from 3 centers treated with keloid excision followed by 2 × 9 Gy, 3 × 6 Gy, or 2 × 6 Gy high-dose-rate brachytherapy were retrospectively compared regarding recurrence (after at least 12 months' follow-up) and complications (after at least 1 month's follow-up), using logistic regression analyses.	To determine the optimal brachytherapy dose and fractionation scheme for keloid treatment.	A total of 238 keloids were treated. An overall full recurrence rate of 8.3% was found. After correction for confounders (sex, skin color, keloid location, keloid duration) no statistically significant differences in recurrence rates could be discerned between fractionation schemes. There were 12.8% major and 45.6% minor complication rates. Lower radiation dose resulted in significantly fewer complications (odds ratio 0.35, P=.015).	3
94	Manjunath KN, Venkatesh MS, Alva R, et al. Efficacy of Surgical Excision and Adjuvant High-dose Rate Brachytherapy in Treatment of Keloid: Our Experience. J Cutan Aesthet Surg. Jul-Sep 2021;14(3):337-343. doi:10.4103/JCAS.JCAS_120_16	Prospective nonrandomized	50 patients with clinically diagnosed 71 keloids were treated with excision of keloid and post-operative high-dose rate brachytherapy were studied. Complete excision of the keloid till the healthy skin margin was excised. The wound were closed in 2 layers. Subcutaneous tissue closed using absorbable suture, over which a 6F flexible polyethylene tube was placed. High dose rate cobalt-60 brachytherapy was administered. Total of 15 Gy in divided dose, 5 Gy in 3 fractions were administered.	To evaluate the feasibility and efficacy surgery and high dose rate brachytherapy as an adjuvant therapy for treatment of keloids.	50 patients with 71 keloids were studied. Out of the 50 patients, 12 were male (24%) and 38 were females (76%). Age of the patients ranged between 14 and 71 years. Recurrence rate was 2% with 2 keloids recurring at 5 months interval. 4 patients scored the results as unacceptable, remaining 45 patients rated their results as excellent during their follow up at 10 days, 3 months and 6 months.	2
95	Daurade M, Breton P, Rouard N, Lorchel F, Ibrahim B, Sigaux N. Efficacy of Surgical Excision and Brachytherapy in the Treatment of Keloids: A Retrospective Cohort Study. Adv Skin Wound Care. Nov 2020;33(11):1-6. doi:10.1097/01.ASW.0000717228.02752.4e	Retrospective	The authors performed a unicentric retrospective cohort study between 2013 and 2018. The minimum follow-up was 12 months. All patients treated for keloids at the authors' institution were included. Extralesional excision was performed with placement of a brachytherapy sheath under the skin. The total dose of irradiation was 18 Gy. The postoperative results were evaluated for aesthetic and	To demonstrate the efficacy of a protocol combining surgical excision and high-dose-rate brachytherapy for treatment of keloids.	Fifteen patients were lost to follow-up. Thirty-eight patients with 67 keloids were included. The control rate was 94%. The aesthetic and functional outcomes were considered good in 62% of cases. The main limitation of the study was the small patient population.	3

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			functional outcomes with a validated scale, as well as the presence or absence of recurrence.			
96	De Cicco L, Vischioni B, Vavassori A, et al. Postoperative management of keloids: low-dose-rate and high-dose-rate brachytherapy. Brachytherapy. Sep-Oct 2014;13(5):508-13. doi:10.1016/j.brachy.2014.01.005	Retrospective	Data on 70 consecutive patients treated after complete keloid surgical excision were retrospectively analyzed. First 38 patients and 46 keloids were treated with adjuvant LDR brachytherapy and the following 39 patients and 50 keloids underwent HDR treatment. Median delivered dose of LDR therapy was 16 Gy; HDR median dose was 12 Gy. Sixty-four keloids (66.7%) were symptomatic at diagnosis with pain, itching, or stress.	To report on the adjuvant low-dose-rate (LDR) and high-dose-rate (HDR) interstitial brachytherapy. Brachytherapy might be useful to improve keloids recurrence rate or reduce keloids treatment side effects instead of external beam radiotherapy.	Fourteen relapses over 46 treated keloids (30.4%) were observed in the LDR group and 19 of 50 keloids (38%) in the HDR group (p = 0.521). Recurrence rate was significantly higher in males (p = 0.009), in patients younger than 44 years (p < 0.0001), for arms, neck, and chest wall anatomic sites (p = 0.0001) and for symptomatic keloids (p = 0.017). Aesthetic outcome was better in case of larger keloids (>8 cm) (p = 0.064). Symptomatic relief was achieved in 92% of HDR patients and only 68% of LDR patients (p = 0.032).	3
97	Arneja JS, Singh GB, Dolynchuk KN, Murray KA, Rozzelle AA, Jones KD. Treatment of recurrent earlobe keloids with surgery and high-dose-rate brachytherapy. Plast Reconstr Surg. Jan 2008;121(1):95-99. doi:10.1097/01.prs.0000293755.64918.22	Retrospective	From Jan 1999 to Dec 2003 25 patients with earlobe keloids following excision receive adjuvant HDR BT using 5 Gy x 3 for a total dose of 15 Gy	To report results on adjuvant HDR brachytherapy following earlobe keloid excision	8% recurrence rate was reported. Infections (n=2), constricted ear deformity (n=1)	3
98	van Leeuwen MCE, Stokmans SC, Bulstra AJ, Meijer OWM, van Leeuwen PAM, Niessen FB. High-dose-rate brachytherapy for the treatment of recalcitrant keloids: a unique, effective treatment protocol. Plast Reconstr Surg. Sep 2014;134(3):527-534. doi:10.1097/PRS.0000000000000415	Prospective nonrandomized	This prospective study included 43 patients of all Fitzpatrick skin types, with 67 keloids in total. After extralesional excision, a radiation scheme of 2 x 6 Gy was administered in two fractions: the first within 4 hours after surgery and the second within 24 hours. Scars were measured and recurrence was judged. Scar appearance was evaluated using the Patient and Observer Scar Assessment Scale.	To report outcomes for keloid patients treated postoperatively with HDR BT	The recurrence rate was 3.1 percent at a mean follow-up of 33.6 months. A significant average scar surface decrease of 56.7 percent was measured (p = 0.01). Complaints of pain and pruritus decreased by 82.9 and 87.2 percent, respectively. Patients were satisfied with the treatment in 88.6 percent of the cases and with the cosmetic result in 77.1 percent. Pigmentation problems were seen in 21.4 percent of the patients, mostly in Fitzpatrick type V and VI/African American individuals.	2
99	Jiang P, Geenen M, Siebert FA, et al. Efficacy and the toxicity of the interstitial high-dose-rate brachytherapy in the management of recurrent keloids: 5-year outcomes. Brachytherapy. May-Jun	Prospective nonrandomized	From 2009 to 2015, 29 patients with 37 recurrent keloids were treated with perioperative interstitial high-dose-rate brachytherapy; 3 patients had been previously treated with	To update long-term results of prospective study for postoperative interstitial HDR BT. Twenty-nine patients	No procedure-related complications occurred. Improvement of keloid-related symptoms was noticed in all patients after treatment. After a median followup of 49.7 months (range: 7.9-91.9 months), three keloid recurrences and two hypertrophied scars were observed.	2

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	2018;17(3):597-600. doi:10.1016/j.brachy.2017.12.002		adjuvant external beam radiotherapy and presented with recurrences in the pretreated area. Brachytherapy was given in three fractions with a single dose of 6 Gy in 5-mm tissue depth and covered the scar in total length. Followup visits were scheduled at 6 weeks, 3 months, 6 months, 1 year, and annually thereafter. Therapeutic outcome was assessed in terms of recurrence, acute and late complications, and cosmetic results.	were included with a median followup of 5 years.		
100	Taheri A, Molaei H, Aghili M, Rahmanpanah N, Mirmohseni A. Outcomes of Surgical Excision and Brachytherapy in Intractable Keloids. World J Plast Surg. Sep 2017;6(3):280-284. PMID: 29218275	Retrospective	Six patients with 10 keloid lesions were followed up. Surgical excision was done with 1-2 mm margin, and then radiotherapy was undertaken in 3 divided fractions on days 0, 1 and 2 after surgery. Scar improvement was evaluated by patients and observer with scar assessment scale (POSAS).	To assess outcomes of surgical excision and brachytherapy in intractable keloids.	Median age of patients was 38.3±6.4, while 40% were male and 60% were female. The mean primary size of the lesion before brachytherapy was 325.18±426.16 mm ² and the median size was 153.48 mm ² . The mean primary size of the lesions with recurrence before brachytherapy was 150.50±124.78 mm ² . The clinical improvement of the scars with POSAS scoring by the observer was 17.1±3.2 and by the patients was 20.8±11.5. In 5 patients who were evaluated, two keloid lesions showed recurrence (20%), and 8 lesions had no recurrence (80%). No patients reported side effects, but only one patient, a 43 years old woman with 5 keloid lesions, suffered wound infection and local dehiscence of the wound, followed by the second session of brachytherapy. The average time of relapse was 26.3±0.9 months.	3
101	Franzetti J, Durante S, Mastroleo F, et al. Post-operative KEloids iRradiation (POKER): does the surgery/high-dose interventional radiotherapy association make a winning hand? Radiol Med. Feb 2024;129(2):328-334. doi:10.1007/s11547-024-01756-4	Prospective nonrandomized	Inclusion criteria were: surgery with a histopathological diagnosis of keloid, subsequent high-dose rate interventional radiotherapy (HDR-IRT)-12 Gy in 4 fractions (3 Gy/fr) twice a day-and follow-up period ≥ 24 months.	To report the results involving post-operative interventional radiotherapy (POIRT) in a homogenous cohort of patients affected by keloid and treated at a single institution with the same fractionation schedule.	One-hundred and two patients and a total of 135 keloids were eligible for the analyses. Median follow-up was 64 [IQR: 25-103] months. Thirty-six (26.7%) recurrences were observed, 12-months and 36-months cumulative incidence of recurrence were 20.7% (95% CI 12.2-28.5) and 23.8% (95% CI 14.9-31.7) respectively. History of spontaneous keloids (HR = 7.00, 95% CI 2.79-17.6, p < 0.001), spontaneous cheloid as keloid cause (HR = 6.97, 95% CI 2.05-23.7, p = 0.002) and sternal (HR = 10.6, 95% CI 3.08-36.8, p < 0.001), ear (HR = 6.03, 95% CI 1.71-21.3, p = 0.005) or limb (HR = 18.8, 95% CI 5.14-68.7, p < 0.001) keloid sites were	2

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					significantly associated to a higher risk of recurrence.	
102	Jiang P, Baumann R, Dunst J, et al. Perioperative Interstitial High-Dose-Rate Brachytherapy for the Treatment of Recurrent Keloids: Feasibility and Early Results. Int J Radiat Oncol Biol Phys. Mar 1 2016;94(3):532-6. doi:10.1016/j.ijrobp.2015.11.008	Prospective nonrandomized	From 2009 to 2014, 24 patients with 32 recurrent keloids were treated with immediate perioperative high-dose-rate brachytherapy; 3 patients had been previously treated with adjuvant external beam radiation therapy and presented with recurrences in the pretreated areas. Two or more different treatment modalities had been tried in all patients and had failed to achieve remission. After (re-)excision of the keloids, a single brachytherapy tube was placed subcutaneously before closing the wound. The target volume covered the scar in total length. Brachytherapy was given in 3 fractions with a single dose of 6 Gy in 5 mm tissue depth. The first fraction was given within 6 hours after surgery, the other 2 fractions on the first postoperative day. Thus, a total dose of 18 Gy in 3 fractions was administered within 36 hours after the resection.	To prospectively evaluate high-dose-rate brachytherapy in the treatment of therapy-resistant keloids and report first results, with emphasis on feasibility and early treatment outcome.	The treatment was feasible in all patients. No procedure-related complications (eg, secondary infections) occurred. Nineteen patients had keloid-related symptoms before treatment like pain and pruritus; disappearance of symptoms was noticed in all patients after treatment. After a median follow-up of 29.4 months (range, 7.9-72.4 months), 2 keloid recurrences and 2 mildly hypertrophied scars were observed. The local control rate was 94%. Pigmentary abnormalities were detected in 3 patients, and an additional 6 patients had a mild delay in the wound-healing process.	2
103	Ahmad M, H. A, Khattack M, et al. Postoperative single versus multiple fractions high-dose rate iridium-192 surface mould brachytherapy for keloid treatment: a comparative study. J Radiother Pract. 2018;17:60-65. doi:10.1017/S1460396917000395	Prospective nonrandomized	From January 2012 to April 2015 a total 51 patients with 65 keloid lesions underwent postoperative Iridium-192 high-dose rate surface mould brachytherapy. The dose regimen used was: 8 Gy in a single fraction, 10 Gy in a single fraction, 15 Gy in three fractions and 18 Gy in three fractions. The median follow-up period was 33 months (range 15–53 months).	To report on high-dose rate Iridium-192 surface mould brachytherapy of keloid scars after surgical excision, using different radiation treatment regimen and to establish the most convenient and cost-effective treatment without treatment compromise	The success rates were 57.2, 89.5, 85 and 89.5% for the treatment regimen of 8 Gy/Fx1, 10 Gy/Fx1, 5 Gy/Fx3 and 6 Gy/Fx3, respectively. Grade 2 or above radiation induced toxicity was not observed.	2

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104	Kuribayashi S, Miyashita T, Ozawa Y, et al. Post-keloidectomy irradiation using high-dose-rate superficial brachytherapy. J Radiat Res. 2011;52(3):365-8. doi:10.1269/jrr.10159	Prospective nonrandomized	Between April 2008 and April 2009, 21 patients with 36 histologically confirmed keloids were treated with postoperative HDR-SB. The tube applicator was placed on the skin to match the area of the surgical wound, and a spacer 5 mm thick was placed between the skin and the applicator. A dose evaluation point was established below 2 mm from skin surface, and 20 Gy was delivered in 4 daily fractions to keloidectomy scars on the anterior chest wall, scapular region, lower jaw and suprapubic region. A dose of 15 Gy was delivered in 3 daily fractions to lesions in other areas.	To evaluate the early results of high-dose-rate superficial brachytherapy (HDR-SB) after keloidectomy.	The median follow-up period was 18 months (range, 9 to 29 months). Therapeutic outcome was judged in terms of recurrence, control, or acute side effects. Three keloids (9.7%) in two patients showed local recurrence, with a median time to failure after HDR-SB of 12 months. All recurrences affected the anterior chest wall. Dysraphia occurred in only one patient with an anterior chest wall lesion. Excluding the cases of recurrence, acceptable cosmetic results were achieved.	2
105	Arnault JP, Peiffert D, Latarche C, Chassagne JF, Barbaud A, Schmutz JL. Keloids treated with postoperative Iridium 192 brachytherapy: a retrospective study. J Eur Acad Dermatol Venereol. Jul 2009;23(7):807-13. doi:10.1111/j.1468-3083.2009.03190.x	Retrospective	This was a retrospective study conducted from November 2006 to November 2007. Patients with clinically and histologically proven KS treated between 1990 and 2005, were convened in consultation between September and October 2007. Clinical data and parameters of the brachytherapy have been collected.	To assess post-excisional brachytherapy with Iridium 192 is a treatment of keloids scars effectiveness and patient satisfaction	Eighty-seven patients (138 KS) were treated. Eighty-two KS (46 patients) met the criteria for inclusion. Thirty-two patients (55 KS) have been seen in consultation. The average time between the onset of KS and treatment was 63.5 months. The brachytherapy has begun after a maximum of 7 hours posterior to surgery for all KS. The average dose was 17.9 Gy calculated at 5 mm. We observed 23.6% of recurrence after treatment. Seventy-nine per cent of itching and 87.5% of pain have totally disappeared. The phototypes 5 and 6 had an increased risk of recurrence.	2
106	Chen S, Mu X, Zhang L, et al. Retrospective study comparing three approaches for keloids: surgery + radiotherapy, surgery + pharmacological injection, and surgery alone. BMC Surg. Aug 23 2025;25(1):386. doi:10.1186/s12893-025-03095-1	Retrospective	A retrospective observational study approach was employed. Clinical data from 121 patients with keloids who met the inclusion criteria were collected for analysis of clinical characteristics and evaluation of treatment efficacy. The patients were categorized into three groups based on the adjuvant treatment modalities utilized post-surgical excision of keloids: surgical + radiotherapy group (group A), surgical + radiotherapy + pharmacological	To investigate the differential efficacy of various treatment modalities adjunct to surgical excision of keloids and to analyze prognostic factors influencing outcomes.	The efficacy rates for group A, group B, and group C were 93.88%, 87.04%, and 55.56%, respectively. Statistical analysis indicated that age and treatment modality were significant risk factors for recurrence.	3

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			injection group (group B), and surgical group (group C). Factors potentially influencing treatment outcomes-such as treatment modality, gender, age, lesion distribution, lesion size, duration of the condition, and prior treatments-were subjected to a statistical analysis. Significant risk factors were identified through univariate analysis.			
107	Gao Y, Li W, Li Z, Wu F, Wang J. Clinical Efficacy Analysis of Botulinum Toxin Type A Combined with Superficial Radiotherapy after Chest Keloid Surgery. <i>Aesthetic Plast Surg.</i> Nov 2025;49(22):6333-6338. doi:10.1007/s00266-025-04886-w	Prospective randomized	60 patients with medium and large chest keloid treated from October 2021 to October 2023 were selected and randomly divided into group A and group B, with 30 cases in each group. Keloid resection was performed in both groups first, group A was treated with BTX-A combined with superficial radiotherapy, group B only received early superficial radiotherapy after surgery, and the therapeutic effect of the two groups was compared.	To observe the clinical effect of BTX-A combined with superficial radiotherapy after chest keloid surgery.	After 6 months follow-up observation, the total effective rate and satisfaction of group A were higher than those of group B, and the Vancouver scar scale(VSS) score of group A was lower than that of group B, the difference was statistically significant (P < 0.05).	1
108	Malaker K, Vijayraghavan K, Hodson I, Al Yafi T. Retrospective analysis of treatment of unresectable keloids with primary radiation over 25 years. <i>Clin Oncol (R Coll Radiol).</i> Jun 2004;16(4):290-8. doi:10.1016/j.clon.2004.03.005	Retrospective	Kilovoltage X-rays and megavoltage electron beams were used to irradiate large bulky unresectable keloids. A total of 3750cGy was given in five once-weekly fractions, over a period of 5 weeks. Eighty-six keloids in 64 patients were treated between 1977 and 2002.	To review retrospectively the role of primary radiotherapy for unresectable keloids.	Ninety-seven per cent of this cohort had significant regression, and 3% had partial regression 18 months after completing radiotherapy. Both acute and long-term reactions were acceptable, and none of the patients were reported as having cancer of any sort. Sixty-three per cent of the patients surveyed were very happy with the outcome of their treatment.	3
109	Yuce Sari S, Yilmaz MT, Yazici G, Uzun H, Yedekci FY, Ozyigit G. A hesitated approach: primary radiotherapy for keloids-a case series. <i>Strahlenther Onkol.</i> Oct 2021;197(10):909-915. doi:10.1007/s00066-020-01736-3	Retrospective	Six patients with a total of 13 inoperable large keloid lesions and no response to previous treatments were admitted to our department between 2017 and 2019. All patients were examined for detailed wound localization, size, contour, and color assessment, and for objective and subjective symptoms. Response to	To assess the efficacy and toxicity of hypofractionated radiotherapy (RT) alone in treatment-resistant symptomatic keloids.	A total dose of 37.5 Gy external RT in five fractions was prescribed by 6-MeV electrons in 4 patients and 6-MV photons in 2 patients. Complete response was obtained in all patients at the 6-month control. All patients were satisfied with cosmetic results at their last control. Grade 2 dermatitis developed in all patients during the second week of RT but resolved completely in all after 6 months following the end of RT.	3

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			treatment was graded as “complete remission” in case of full symptomatic relief and >75% decrease in lesion size, as “partial remission” in case of partial symptomatic relief and 25–75% decrease in lesion size, and as “stable disease” in case of no symptomatic relief or <25% decrease in lesion size. Patients were followed up monthly for the first 3 months and every 3 months thereafter by physical examination.			
110	Fernandes J, Liao D, Dasgupta A, Tsao MN, Barnes EA. A Single-Institution Review of the Use of Radiation in the Adjuvant and Definitive Management of Keloids. Clin Oncol (R Coll Radiol). Jun 2024;36(6):e163-e167. doi:10.1016/j.clon.2024.03.018	Retrospective	A retrospective review of patients treated with radiation therapy for keloids between 2014 and 2020 at our institution was performed.	To review institutional data for radiation therapy for keloid management.	A total of 70 keloids in 41 patients were treated. For the 55 keloids treated with post-operative radiation therapy (16Gy delivered in 2 fractions), 82.5% (33/40) of evaluable lesions did not recur. Among the 15 keloids treated with definitive radiation therapy (24Gy delivered in 3 fractions), 78.6% (11/14) of evaluable keloids showed complete flattening, and 14.3% (2/14) had partial flattening. Both acute and late toxicities were mild, with only a single instance of grade 3 toxicity (dermatitis).	3
111	Tsai TL, Huang YC, Chang YH, et al. Outcomes of Primary Radiation Therapy for Patients With Widespread or Unresectable Keloids. Pract Radiat Oncol. Feb 26 2026;doi:10.1016/j.prro.2026.02.007	Retrospective	We retrospectively reviewed 35 patients with 64 keloid lesions treated with primary radiation therapy between January 2010 and July 2023. All received 30 Gy in 6 fractions. Treatment modalities, including 6 MeV or 9 MeV electrons and photon-based intensity modulated radiation therapy, were individualized according to lesion thickness and anatomic complexity. Clinical improvements were evaluated using the Visual Analog Scale, Vancouver Scar Scale, and Japan Scar Workshop Scar Scale. Longitudinal outcomes were analyzed using generalized estimating equations.	To evaluate the clinical outcomes of primary radiation therapy as a definitive treatment for widespread or unresectable keloids.	Prominent symptomatic relief and cosmetic improvement were achieved with primary radiation therapy, with significant and sustained reductions in the Visual Analog Scale, Vancouver Scar Scale, and Japan Scar Workshop scores during follow-up. Disease control was excellent, with no cases of recurrence or serious adverse events.	3

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112	Guix B, Henriquez I, Andres A, Finestres F, Tello JI, Martinez A. Treatment of keloids by high-dose-rate brachytherapy: A seven-year study. <i>Int J Radiat Oncol Biol Phys.</i> May 1 2001;50(1):167-72. doi:10.1016/s0360-3016(00)01563-7	Prospective nonrandomized	One hundred and sixty-nine patients with keloid scars were treated with HDR brachytherapy between December 1991 and December 1998. 134 were females, and 35 were males. T: face, 77; trunk, 73; and extremities, 19. The mean length was 4.2 cm (range 2-22 cm), and the mean width 1.8 cm (range 1.0-2.8 cm). In 147 keloid tissues were removed before HDR brachytherapy treatment, and in 22 HDR brachytherapy was used as definitive treatment. HDR brachytherapy was administered within 30-60 min of surgery. A total dose of 12 Gy (at 1 cm from the center of the catheter) was given in 4 fractions of 300 cGy in 24 h (at 09.00 am, 15.00 pm, 21.00 pm, and 09.00 am next day). In patients who did not undergo surgery, a total dose of 18 Gy was given in 6 fractions of 300 cGy in one and a half days (at 9.00 am, 3.00 pm, and 9.00 pm; and at 9.00 am, 3.00 pm, and 9.00 pm next day). No further treatment was given to any patient. No patient was lost to follow-up.	To analyze the results obtained in a prospective group of patients with keloid scars treated by high-dose-rate (HDR) brachytherapy with or without surgery.	All patients completed the treatment. After a follow-up of seven years, 8 patients (4.7%) had keloid recurrences. Five of these had undergone prior surgery (local failure rate 3.4%), and 3 had received only HDR brachytherapy (local persistence rate 13.6%). Cosmetic results were considered to be good or excellent in 130/147 patients treated with prior surgery and in 17/22 patients without surgery. Skin pigmentation changes were observed in 10 patients, and telangiectasias in 12 patients. No late effects such as skin atrophy or skin fibrosis were observed during the 7 years of follow-up.	2
113	Deng K, Xiao H, Liu X, Ogawa R, Xu X, Liu Y. Strontium-90 brachytherapy following intralesional triamcinolone and 5-fluorouracil injections for keloid treatment: A randomized controlled trial. <i>PLoS One.</i> 2021;16(3):e0248799. doi:10.1371/journal.pone.0248799	Prospective randomized	We included keloid patients from March 2019 to September 2019 and randomly allocated them to two groups after 3 intralesional triamcinolone and 5-fluorouracil injections at 3 weeks interval. The experimental group received Strontium-90 brachytherapy at a total dose of 15-20Gy, while the control group didn't receive any adjuvant treatment. We performed both Vancouver Scar Scale scoring and Color Doppler	To determine whether and how Strontium-90 brachytherapy as an adjuvant radiation could affect keloid recurrence after intralesional triamcinolone and 5-fluorouracil injections.	31 patients who had 42 keloids in total were recruited. We found intralesional triamcinolone and 5-fluorouracil injections could effectively reduce the thickness and modify the hardness of small and young keloids. Strontium-90 brachytherapy reduced the one-year recurrence rate from 85.7 percent to 44.4 percent after 3 intralesional triamcinolone and 5-fluorouracil injections. The lesions' thickness or elasticity was not affected by Strontium-90 brachytherapy.	1

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			ultrasound examination to monitor and evaluate lesions regularly. A one-year follow-up was completed for each patient.			
114	Ma QY, Yang YT, Chen ZA, et al. Laser Combined with Radiotherapy for Keloid Treatment: A Novel and Efficient Comprehensive Therapy with a Lower Recurrence Rate. <i>Plast Reconstr Surg.</i> Dec 1 2023;152(6):1022e-1029e. doi:10.1097/PRS.00000000000010376	Retrospective	A total of 99 patients with keloids in 131 positions were included in this retrospective study. Fractional CO ₂ laser therapy was first applied with energy ranging from 360 to 1008 mJ; then, 6-Mev, 900-cGy electron beam irradiation was applied twice. The first pass was initiated within 24 hours after the laser therapy, and the second pass was performed on the seventh day after laser therapy. The Patient and Observer Scar Scale evaluated the lesions before the treatment and at 6, 12, and 18 months after treatment. At each follow-up visit, the patients filled out a questionnaire on recurrence, side effects, and satisfaction.	To evaluate laser combined with RT as an ablative therapy for keloids	The authors found a significant decrease in total Patient and Observer Scar Scale score [29 (23, 39) versus 61.2 ± 13.4; P < 0.001] at the 18-month follow-up compared with the baseline value (before the therapy). A total of 12.1% of the patients had recurrences during the 18-month follow-up period (11.1% partial recurrence and 1.0% complete recurrence). The total satisfaction rate was 97.0%. No severe adverse effects were observed during the follow-up period.	3
115	Wu B, Zhang B, Xiao H, Xu X. Combining Steroid Plus 5-Fluorouracil Injection with Radiotherapy Versus Injection Alone for Keloids: A 4-Year Retrospective Study. <i>Aesthetic Plast Surg.</i> Dec 2025;49(23):6743-6755. doi:10.1007/s00266-025-04927-4	Retrospective	e retrospectively reviewed patients who were initially treated between 2019 and 2022 and followed for more than 12 months. The baseline condition, the Vancouver Scar Scale (VSS), recurrence, symptoms, follow-up period, and patient self-assessment were recorded.	To evaluate the safety and efficacy of combining intralesional triamcinolone acetonide (TAC) + 5-fluorouracil (5-FU) injection with electron beam radiotherapy or brachytherapy compared to intralesional TAC+5-FU injection alone.	The study included a cohort of 100 eligible patients with a total of 111 keloids. Seventy-one of patients received the combined therapy and 29 received TAC+5-FU injection only. The results revealed that combining injection with radiotherapy reduced the recurrence rate and improved symptoms such as pruritus and pain while posing minimal extra risk of side effects. Moreover, patients receiving combined therapy assessed treatment outcomes more positively than those solely receiving injection therapy. Other factors that related to increased risk of recurrence included a higher VSS score at the end of treatment and the presence of keloid family history.	3
116	Hadedeya D, Shalaby M, Akkera M, Lee G, Harris K, Kholmatov R, et al. Prophylactic external beam radiation therapy for keloid prevention in thyroid surgery patients. <i>Gland Surg.</i> 2021;10(1):65-72. doi: 10.21037/gs-20-511	Retrospective	A series of ten patients, who underwent a prophylactic EBRT for keloid prevention after thyroid surgery between January 2013 and February 2019. Patient demographics, primary diagnosis, surgical procedure, EBRT dosage,	To examine the use of prophylactic RT following thyroid surgery with the goal of prevent de novo keloid formation.	All ten patients who received EBRT for keloid prophylaxis following a thyroid surgery were female. Half of the patients were African Americans, 40% Caucasians, and 10% Hispanic. The mean age was 46.40±15.63 years with BMI of 31.5±5.5 kg/m ² . Radiation was initiated within 6 hours of the surgery with an average radiation	3

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			and post-operative visit records were reviewed.		dose per session of 5.7±1.7 Gy. The total average EBRT dose delivered was 17.4±4.2 Gy. Mean follow-up period was 13 months post-thyroidectomy, with the longest follow-up at 23 months. One patient, who underwent a lateral neck dissection in addition to thyroid surgery, developed hypertrophic scar in less than 10% of her incision length. Nine other patients (90%) showed no post-surgical keloid nor hypertrophic scar formation and patients were satisfied with postsurgical cosmesis.	
117	Hwang NH, Chang JH, Lee NK, Yang KS. Effect of the biologically effective dose of electron beam radiation therapy on recurrence rate after keloid excision: A meta-analysis. Radiother Oncol. Aug 2022;173:146-153. doi:10.1016/j.radonc.2022.06.003	Systematic review and meta-analysis	A literature search was performed in PubMed, Embase, and the Cochrane Library for the period from 1990 to December 2021. Studies that provided information on the recurrence rate for the exact prescription dose were selected for analysis. The recurrence rate with respect to the BED was evaluated using forest plots and the best-fit lines on scatter plots.	To perform a meta-analysis of studies on hypofractionated electron beam radiation therapy after keloid excision based on accurate radiation dose information to provide a more precise estimate of the effect of the biologically effective dose (BED) on recurrence rate.	From the 28 studies that were included for analysis, a total of 37 radiation dose datasets were extracted and 3128 excised keloids were identified. The recurrence rate for all sites and for the ear was 0.16 (95% confidence interval, 0.12-0.21; P < 0.01) and 0.11 (95% confidence interval, 0.06-0.20; P < 0.01), respectively. The estimated recurrence rate for all sites and the ear was calculated as "-1.992 + 1018.226/BED2" or "2.982 + 330.51/BED10" and "-16.8 + 1597.84/BED2" or "-14.65 + 656.58/BED10," respectively.	M
118	Kal HB, Veen RE. Biologically effective doses of postoperative radiotherapy in the prevention of keloids. Dose-effect relationship. Strahlenther Onkol. Nov 2005;181(11):717-23. doi:10.1007/s00066-005-1407-6	Systematic review and meta-analysis	A literature search was performed to identify studies dealing with the efficacy of various irradiation regimens for the prevention of keloids after surgery. Biologically effective doses (BEDs) of the various irradiation regimens were calculated using the linear-quadratic concept. A distinction between recurrence rates of keloids in the face and neck region and those in other parts of the body was made.	To review the recurrence rates of keloids after surgical excision followed by radiotherapy, and to answer the question whether after normalization of the dose, a dose-effect relationship could be derived.	31 reports were identified with PubMed with the search terms keloids, surgery, radiation therapy, radiotherapy. 13 reports were excluded, because no link could be found between recurrence rate and dose, or if less than ten patients per dose group. The recurrence rate for surgery only was 50-80%. For BED values > 10 Gy the recurrence rate decreased as a function of BED. For BED values > 30 Gy the recurrence rate was < 10%. For a given dose, the recurrence rates of keloids in the sites with high stretch tension were not significantly higher than in sites without stretch tension. The results of this study indicate that for effectively treating keloids postoperatively, a relatively high dose must be applied in a short overall treatment time. The optimal treatment probably is an irradiation scheme resulting in a BED value of at least 30 Gy. A BED value of 30 Gy	M

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					can be obtained with, for instance, a single acute dose of 13 Gy, two fractions of 8 Gy or three fractions of 6 Gy, or a single dose of 27 Gy at low dose rate. The radiation treatment should be administered within 2 days after surgery.	
119	van Leeuwen MC, Stokmans SC, Bulstra AE, et al. Surgical Excision with Adjuvant Irradiation for Treatment of Keloid Scars: A Systematic Review. <i>Plast Reconstr Surg Glob Open</i> . Jul 2015;3(7):e440. doi:10.1097/GOX.0000000000000357	Systematic review and meta-analysis	A systematic review of the English-language literature, based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement. Both PubMed and EMBASE were searched.	To report the results of a systematic review and meta-analysis. Studies were graded according to the American Society of Plastic Surgeons Rating Levels of Evidence for (1) the use of high-dose-rate brachytherapy instead of low-dose-rate brachytherapy or external radiation; (2) a short-time interval between operation and irradiation; (3) single fraction instead of multifraction irradiation; and (4) a minimum of 12- to 24-month follow-up post treatment.	Thirty-three studies were selected. Six studies were graded as level of evidence type II studies and 27 as type III. High-dose-rate brachytherapy showed lower recurrence rates compared with low-dose-rate brachytherapy and external radiation. A short-time (<7 hours) interval between scar excision and irradiation results in a lower recurrence rate compared with long-time intervals (>24 hours). Single-fraction irradiation showed promising results in terms of recurrence rate and patient convenience. Finally, scar recurrences were seen between 2 and 36 months, with a mean of 15 months.	M
120	Zhou W, Li B, Yin Y, et al. Treatment outcomes of surgery followed by short-course every other day radiotherapy in keloid. <i>Radiat Oncol</i> . Jul 17 2024;19(1):91. doi:10.1186/s13014-024-02488-5	Retrospective	We conducted a retrospective analysis of 498 patients with keloids treated at our institution between January 2010 and December 2017. All patients underwent electron beam irradiation at a dose of 16 Gy, delivered in four fractions every other day, starting within 24 h post-surgery. The primary endpoint of the study was the local control rate.	To evaluate the effectiveness of surgery followed by a short-course of radiotherapy administered every other day for keloid treatment.	A total of 130 (26.5%) keloids recurred after a median follow-up of 68.1months (42.6-129.9 months). The local control rates at 1 year, 3 years and 5 years for all patients were 89.5%, 82.5% and 81%, respectively. The highest recurrence rate was observed in keloids located in the chest region (50.8%), followed by the suprapubic (47.8%), head and neck (38.8%), limbs (33.3%) and ear (14%). Both multivariate and univariate analyses identified the presence of pain and or pruritus as an independently prognostic factor for keloid recurrence (p<0.0001). The local control rates at 1-year, 3-years and 5-years for patients with or without symptom of pain or pruritus were 45% vs.	3

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					98.8%, 12.5% vs. 95.9%, and 8.8% vs. 95%, respectively (HR:37.829, 95%CI: 24.385-58.686, p<0.001). In the ear keloid subgroup, the 1-year, 3-year and 5-year local control rates for patients with pruritus were significantly lower than those without pain or pruritus (60.0% vs. 97.9%, 26.7% vs. 94.7%, 26.7% vs. 94.3%, HR:30.209, 95% CI:14.793-61.69, p<0.001). The same results were found in other location(p<0.001). During treatment and follow-up, two patients experienced infections, and one patient developed a cutaneous fibroblastoma.	
121	Peng Q, Lu Y, Huang R, Chen R. Should We Do Postoperative Radiotherapy After Keloid Excision as Soon as Possible? A Systematic Review and Meta-Analysis. Aesthetic Plast Surg. Aug 2025;49(16):4671-4682. doi:10.1007/s00266-025-04869-x	Systematic review and meta-analysis	A systematic review and meta-analysis were conducted on observational studies by searching PubMed, Embase, and the Cochrane Library. The pooled estimate of the keloid recurrence rate was calculated using a random-effects model. Subgroup analyses were conducted based on time, overtime, BED, length, and location of keloid.	To investigate the appropriate time of radiotherapy for keloid in the first 24 hours after operation and identify the potential risk factors.	Eight observational studies with 507 keloids met the inclusion criteria, and 7 studies were finally included in this study after sensitivity analysis. The recurrence rate was lower in the 2 hours postoperative radiotherapy group (7% CI 2-14%) than in the 6 hours postoperative radiotherapy group (16%, CI 3-36%) (P<0.01). In HDR subgroup analysis, the 2 hours group was better than the 6 hours group ((5%, CI 1-14%) versus (16%, CI 3-36.1%) (P<0.01). Subgroup analysis based on BED indicated that the BED 30 group (5%, CI 1-14%) had a lower recurrence rate than the BED 20 group (6%, CI 0-21%) and the BED 15 group (26%, CI 19-33%) (P<0.01). The keloid length >5 cm subgroup (10.4%, CI 0.4-29%) showed a higher recurrence rate than the keloid length <5 cm group (9.9%, CI 0-41%) (P=0.011).	M
122	Maemoto H, Ishigami K, Iraha S, et al. Analyses of size and computed tomography densitometry parameters for prediction of keloid recurrence after postoperative electron beam radiation therapy. Skin Res Technol. Jan 2020;26(1):125-131. doi:10.1111/srt.12775	Retrospective	The size and CT densitometry parameters were measured for 74 lesions with CT images of sufficient quality for evaluation. The association between recurrence and size or CT densitometry parameters was analyzed for 64 lesions that could be followed up for 6 months or more.	To investigate computed tomography (CT) densitometry parameters of keloids as potential predictors for recurrence after postoperative radiotherapy.	The major axis diameter × minor axis diameter × thickness showed the strongest correlation with volume (p = 0.96, P < .0001). The median follow-up period was 71 months, and 17 lesions recurred. The major axis diameter × minor axis diameter × thickness ≥2.5 cm3 (hazard ratio = 5.9, P = .0052) and volume ≥1.2 ml (hazard ratio = 4.3, P = .029) were significantly associated with keloid recurrence under multivariate analyses, while the major axis diameter alone were not. The mean and maximum CT values, and the kurtosis and skewness of density histogram were not significantly different between recurrent and non-recurrent lesions.	3

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123	Goutos I, Ogawa R. Brachytherapy in the adjuvant management of keloid scars: literature review. Scars Burn Heal. Jan-Dec 2017;3:2059513117735483. doi:10.1177/2059513117735483	Review	An English literature review was performed with keywords 'brachytherapy' and 'keloid' using the databases PubMed, Embase and Web of Science from their individual dates of inception until June 2017. Studies pertinent to the field are presented in a chronological manner to depict the evolution of different brachytherapy strategies over the last decades. We also discuss considerations relating to the risk of secondary carcinogenesis, which are relevant to shared decision-making in the clinical setting.	To review data for brachytherapy for treatment of keloids	Low dose rate interstitial brachytherapy was first introduced in the English literature in 1976 and currently appears to have been superseded by more modern approaches, including high dose rate interstitial brachytherapy. This modality compares favourably to more traditional modes of radiotherapy in terms of recurrence as well as rates of symptomatic relief from keloidal symptoms. Superficial brachytherapy was introduced more recently in the relevant literature and appears to be associated with favourable therapeutic outcomes compared to external beam radiation therapy.	4
125	Nestor MS, Berman B, Goldberg D, et al. Consensus Guidelines on the Use of Superficial Radiation Therapy for Treating Nonmelanoma Skin Cancers and Keloids. J Clin Aesthet Dermatol. Feb 2019;12(2):12-18. PMID: 30881578	Systematic review and guidelines	A search of the medical literature was performed to obtain published information on the use of SRT for review. A group of qualified dermatologists convened to discuss their views on the use of SRT for the treatment of NMSCs and recurrent keloids. The various guidelines were considered to have consensus based on a supermajority two-thirds vote. The final consensus guidelines are thus based on the medical literature, when available, and expert opinions.	To provide consensus guidelines on the use of SRT for treating NMSC and recurrent keloids based on a review of the literature and expert opinion.	Agreement on consensus guidelines was reached for numerous aspects of SRT use, including appropriate tumor types for SRT; anatomical areas suitable for SRT; energy, fractions, and scheduling recommendations for SRT; use of SRT in the presence of comorbidities; safety factors; and treatment recommendations for recurrent keloids, based the literature and on both the opinions of the expert group and a survey of experienced users.	4
126	Ogawa R, Yoshitatsu S, Yoshida K, Miyashita T. Is radiation therapy for keloids acceptable? The risk of radiation-induced carcinogenesis. Plast Reconstr Surg. Oct 2009;124(4):1196-1201. doi:10.1097/PRS.0b013e3181b5a3ae	Systematic review	A computerized literature search was carried out using PubMed that included citations from MEDLINE and PubMed Central between 1901 and March of 2009. The following search terms were used: "keloid(s)," "hypertrophic scar(s)," "radiation," "radiation therapy," "radiotherapy," "carcinogenesis," "carcinoma," "cancer," "complications," and "side effects." Moreover, the references	To investigate associations between carcinogenesis and keloid radiation therapy, and examined the evidence-based opinions of radiation oncologists regarding the acceptability of using radiation to treat keloids.	The authors located five cases of carcinogenesis (i.e., fibrosarcoma, basal cell carcinoma, thyroid carcinoma, and breast carcinoma) that were associated with radiation therapy for keloids. However, it was unclear whether an appropriate dose of radiation was used and whether sufficient protection of surrounding tissues was provided. Moreover, a questionnaire study of radiation oncologists around the world revealed that approximately 80 percent considered radiation to be acceptable for treating keloids.	3

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			for each report were also retrieved.			
127	Li L, Yuan C, Zhang X, Wang B, Yan Y. Superficial X-ray-induced hyperpigmentation in postoperative keloid radiotherapy: A study of 70 keloids to identify clinical features and risk factors. J Cosmet Dermatol. Sep 2021;20(9):2880-2886. doi:10.1111/jocd.14308	Retrospective	From November 2019 to November 2020, 70 keloids in 55 patients were treated with superficial X-ray after surgery. Patient data and treatment-related parameters were collected. Follow-up photographs were taken one month after radiotherapy. Three independent dermatologists assessed photographs for pigmentation. The clinical characteristics and severity of pigmentation were summarized. Logistic regression was used to analyze the risk factors associated with occurrence and severity of hyperpigmentation.	To identify clinical features and risk factors of superficial X-ray-induced hyperpigmentation in postoperative keloid radiotherapy.	The pigmentation was a well-defined rectangular brown macule consistent with the unprotected area that involves normal skin, and 82.9% of keloids displayed pigmentation induced by superficial X-ray at one month after treatment. All keloids of trunk appeared to be mild-to-moderately hyperpigmented (100%); 92.89% of limb keloids displayed mainly severe pigmentation. Keloid location was an independent risk factor for the incidence and severity of pigmentation. Longer incision length was also predictive of increased hyperpigmentation severity.	3
128	Berman B, Nestor MS, Gold MH, Goldberg DJ, Weiss ET, Raymond I. A Retrospective Registry Study Evaluating the Long-Term Efficacy and Safety of Superficial Radiation Therapy Following Excision of Keloid Scars. J Clin Aesthet Dermatol. Oct 2020;13(10):12-16. PMID: 33584951	Retrospective	Medical records were reviewed of subjects treated for keloid scars followed by SRT (SRT-100™; Sensus Healthcare, Boca Raton, Florida) using a biologically effective dose (BED) of 30Gy and for whom the required retrospective data was available. Eligible subjects (N=61) were treated for 96 keloid scars with SRT. Subjects were male (48%) and female (52%) with a mean age of 38.87 years. Subjects were treated for ≥1 keloid scars following removal by sutured excision (93%) or tangential excision with secondary intention technique (7%). Almost all subjects (98%) received BED 30Gy with irradiation scheme of three 6Gy SRT treatments on Days 1, 2 and 3 following surgery. Mean energy of 100KV (73%) or 70KV (27%) were applied.	To assess keloid recurrence rates when superficial radiation therapy (SRT) was applied following surgical excision.	en treated keloidectomy sites (10.4%) had recurrences (i.e., presence of any new tissue growth on the surgical scar) within 12 months increasing to 11 (12.7%) at 18 months. Kaplan-Meier survival probability cure rate was 85.6% from 24 months post-SRT treatment onwards. Transient hyperpigmentation was the most frequent adverse event and there were no malignancies in the treatment area during follow-up evaluations. SRT with a BED value of 30 Gy delivered to keloidectomy excision sites immediately following excision was well-tolerated and resulted in markedly fewer long-term recurrences than reported following keloidectomy alone. Most keloid scar recurrences occurred within one year. There were no malignancies during follow-up evaluations.	3

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129	Duan Q, Liu J, Luo Z, Hu C. Postoperative brachytherapy and electron beam irradiation for keloids: A single institution retrospective analysis. <i>Mol Clin Oncol</i> . May 2015;3(3):550-554. doi:10.3892/mco.2015.498	Retrospective	A retrospective review was performed of 116 keloid patients who underwent postoperative brachytherapy and electron beam irradiation between January 1, 2002 and June 30, 2012. Several different radiotherapy techniques and fractionation schedules were performed in the analysis, including high-dose rate (HDR) irradiation with 192Ir at 8 Gy/1 fraction (F)+9 Gy/3F or 20 Gy/4F; HDR brachytherapy with 60Co at 20 Gy/4F or 18 Gy/6F; or external beam electron therapy at 26 Gy/13F or 30 Gy/15F. The endpoints of the study were analysis of the control rate and toxicity.	To perform a retrospective analysis of the control rate and toxicity of postoperative brachytherapy and electron beam irradiation for keloids.	The median observation period was 46.5 months (range, 10.0-120.0 months) for all patients. In total, 18 of the 116 patients relapsed, and 16.7 months (range, 10.0-30.0 months) was the median time to recurrence for these patients. The control rates for the patients who received hypofractionation (>2 Gy per fraction) and conventional fraction (2 Gy per fraction) were 88.5 and 76.3%, respectively (P=0.043). The control rates for the patients whose calculated biological effective doses (BED) were >30 Gy and <30 Gy were 89.7 and 79.3%, respectively (P=0.104). There were no grade 2 or higher adverse effects based on the Common Terminology Criteria for Adverse Events v3.0 in the late phase. No evidence was identified for a link between radiotherapy and the subsequent occurrence of cancer. The results of the present study indicate that hypofractionated radiotherapy played an important role as an adjuvant therapy following surgical excision of keloids. A BED of >30 Gy appears to be sufficient.	3
130	Bischof M, Krempien R, Debus J, Treiber M. Postoperative electron beam radiotherapy for keloids: objective findings and patient satisfaction in self-assessment. <i>Int J Dermatol</i> . Sep 2007;46(9):971-5. doi:10.1111/j.1365-4632.2007.03326.x	Prospective nonrandomized	Forty-seven patients with a combined total of 60 keloids were treated with 6-MeV electron beam radiotherapy after surgical excision of the keloids. Mean daily fractions of 4 Gy (range, 3–5 Gy) were administered up to a total dose of 16 Gy (range, 12–18 Gy). The median follow-up was 70 months. Patients were asked to complete a questionnaire addressing their satisfaction with the treatment results. This self-assessment was compared with the clinical outcome.	To evaluate the role of postoperative radiotherapy in the management of keloids.	Four keloids (7%) relapsed completely, and five recurrences (8%) were classified as limited relapses. All recurrences were observed at sites of high stretch–tension. Keloid-associated symptoms, e.g. itching and pain, were improved in 81%. Hypopigmentation was observed in 29 patients (62%), a mild redness of the scar in eight patients (17%), and grade 1 telangiectasias in two patients (4%). No severe complications or secondary malignancies were observed. Self-assessments did not fully correspond to the clinical examination and recurrence status. Twelve patients were not satisfied with the treatment result, but only two of these relapsed completely. Three relapsed patients described the result of therapy as excellent or good.	2
131	Doornbos JF, Stoffel TJ, Hass AC, et al. The role of kilovoltage irradiation in the treatment of keloids. <i>Int J Radiat Oncol Biol Phys</i> . Apr 1990;18(4):833-9. doi:10.1016/0360-3016(90)90405-9	Retrospective	Singlue institution data from 203 excised keloids	To report the results of kilovoltage irradiation given to prevent the regrowth of 203 keloids excised	We found that a minimum follow-up of 1 year is needed to evaluate the results of post-excisional kilovoltage x-ray therapy. A dose versus response effect was also observed. Although it is desirable to use the lowest possible dose of radiation that is likely to be effective, the likelihood of failure is too	3

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					great to justify the routine use of doses of less than 900 cGy regardless of how they are fractionated or when they are given. It appears that the total dose of irradiation that is given to prevent the regrowth of an excised keloid is more important than when irradiation is started, the size of the largest fraction given, whether the irradiation is completed in 1 week or 3, or where the keloid has grown. When a small number of keloids were irradiated less than 1 year after they first appeared greater than or equal to 1500 cGy were sufficient to control 90% of them without re-excision.	
132	Kovalic JJ, Perez CA. Radiation therapy following keloidectomy: a 20-year experience. Int J Radiat Oncol Biol Phys. Jul 1989;17(1):77-80. doi:10.1016/0360-3016(89)90373-8	Prospective nonrandomized	We followed 75 patients with 113 keloids for a mean time of 9.75 years. Seventy-four percent of the lesions involved the earlobe. Superficial X ray therapy was used in 89% of the cases. The most frequent dose schedule was 12 Gy in three fractions over 3 days.	To report outcomes for 113 keloids treated with adjuvant RT	The overall control rate was 73%. There was no advantage to starting radiation within 1 day of surgery. Keloids greater than 2 cm in size, those that had previous therapy, and those occurring in men were found to indicate a high likelihood of recurrence. The mean time to recurrence was 12.8 months. There were no complications reported	2
133	Borok TL, Bray M, Sinclair I, Plafker J, LaBirth L, Rollins C. Role of ionizing irradiation for 393 keloids. Int J Radiat Oncol Biol Phys. Oct 1988;15(4):865-70. doi:10.1016/0360-3016(88)90119-8	Retrospective	Between 1928 and 1986, 393 keloid sites on 250 patients were presented. Three hundred seventy-five sites received superficial quality therapeutic irradiation. Etiologies were determined. The majority were excised prior to irradiation, and in these, histologic confirmation was obtained.	To report outcomes for 250 patients treated with RT for keloids after excision	Recurrence rate after irradiation was low, 9/375 (2.4%). When 7 of 9 recurrences are eliminated for post-irradiation ear lobe repiercing, true recurrence is only 2/375 (0.53%). Cosmetic result was considered excellent without recurrence in 92%; favorably improved with hypertrophic scar, nodule or altered pigment in 5.6%; and marginally improved with smaller, less symptomatic keloid in 2.4%. Significant complications were limited to persistent pigment disturbance in only 1 patient, and pre-irradiation hemorrhage in 1 patient (unrelated to radiotherapy). There was no wound dehiscence nor failure to heal irradiated incision site. Transient hyperpigmentation occurred in 91/375 (24%). Recurrence after irradiation was too rare to associate with etiology, specific technical factors, keloid configuration or velocity of initiating the post-operative radiotherapy. An unexpected finding was that 22/250 (9%) were Caucasian.	3
134	Grobien M, Quero L, Chaouat M, et al. Treatment of refractory keloid by postoperative HDR brachytherapy: An 89-month median follow-up retrospective	Retrospective	Inclusion criteria included the presence of one or more keloid scars and histological confirmation of the diagnosis. Exclusion criteria	To assess the percentage of long-term recurrence and look for the presence	A total of 87 keloids scare were eligible for the analysis. Median follow-up was 89,7 months (IQR: 60.2–120.2). 34 recurrences (39%) were observed. Of these recurrences, 41% (14 of 34) showed a	3

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	study. Brachytherapy. Nov-Dec 2025;24(6):940-948. doi:10.1016/j.brachy.2025.08.003		comprised a history of keloid surgery other than simple excision, and the absence of intraoperative direct suturing of the scar.	of influencing factors.	significant reduction in keloid volume, 29% (10 of 34) returned to the original keloid volume, and 29% (10 of 34) demonstrated an increase in volume. The recurrence-free survival for all cheloid was 0.89 [0.45;0.98] at one year and 0.67 [0.28;0.89] at 5 years. Keloid of the ear compared to other sites (HR = 0.38, 95% CI: 0.17–0.85, p = 0.02) was significantly associated with a lower recurrence risk. Male sex (HR = 2.13, 95% CI: 0.88–5.14, p = 0.09) and prior treatment (HR = 3.44, 95% CI: 0.85–13.89, p = 0.08) were associated with RR	
135	Viani GA, Stefano EJ, Afonso SL, De Fendi LI. Postoperative strontium-90 brachytherapy in the prevention of keloids: results and prognostic factors. Int J Radiat Oncol Biol Phys. Apr 1 2009;73(5):1510-6. doi:10.1016/j.ijrobp.2008.07.065	Retrospective	Data of 612 patients with 892 keloids treated between 1992 and 2006 were evaluated retrospectively. Brachytherapy was performed using a Sr-90Y surface applicator. Total dose was 20 Gy in 10 fractions.	To evaluate the results of keloidectomy and strontium 90 brachytherapy in the prevention of keloid recurrence following excision and to identify outcome and the prognostic factors that predict keloid recurrence after irradiation.	With a median follow-up of 61 months, the overall recurrence-free response rate for all keloids was 87.6%. Multivariate analysis revealed the following prognostic factors for recurrence: keloid size > 5 cm (p < 0.0001), burn scars as the keloid etiology (p < 0.0001), and previous treatment (p < 0.0001). Outcome was not found to be significantly related to the interval between surgery and radiotherapy, sex, or age. Pruritus and skin reddening were the most common symptoms of keloids, but all signs and symptoms abated with time after treatment. Cosmetic results from the keloid treatment were considered good or excellent in 70.6%	3
136	Wagner W, Alfrink M, Micke O, Schafer U, Schuller P, Willich N. Results of prophylactic irradiation in patients with resected keloids--a retrospective analysis. Acta Oncol. 2000;39(2):217-20. doi:10.1080/028418600430806	Retrospective	The data of 139 patients with 166 keloids treated postoperatively between 1962 and 1996 were evaluated for prognostic factors and outcomes. Treatment commenced within 48 h after surgery. Radiotherapy was carried out as brachytherapy, using an integrated radionuclide 90 Sr-90Y surface applicator. The median dose delivered to the subcutis amounted to 14 Gy (7.5-28.5 Gy).	To report outcomes for use of postoperative strontium surface applicator following keloid excision	The overall recurrence-free response rate was calculated to be 80% for all keloids. Response rates differed significantly (p < 0.001) between the different anatomical regions. The recurrence rate was lowest (2%) with keloids of the face and neck and highest with keloids of the thorax (49%). Outcome also differed significantly, depending on the etiology. Keloids following burns had a poorer success rate than those developing after surgery or mechanical trauma (p < 0.001). We were unable to demonstrate any significance in outcome related to gender, age or size. No direct correlation was found between total doses and response rates.	3
137	Escarmant P, Zimmermann S, Amar A, et al. The treatment of 783 keloid scars by iridium 192 interstitial irradiation after surgical excision. Int J Radiat Oncol Biol Phys. May 20 1993;26(2):245-51. doi:10.1016/0360-3016(93)90204-9	Retrospective	Between 1977 and 1988, 544 patients, with a total of 855 keloids, were treated by interstitial radiotherapy immediately following total excision.	To confirm the effectiveness of irradiation associated with surgery in the treatment of keloids	Recurrence rate is 21%, as against 50 to 80% for surgery alone, according to most authors. This recurrence rate is about the same as for external radiotherapy, but we prefer our method for practical reasons (cost, equipment, radiobiology, technique). Ninety percent of recurrences occurred in the year following therapy.	3

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Article Key:

Of the 137 references cited in the American Radium Society® Appropriate Use Criteria for Adjuvant Radiotherapy for the Prevention of Recurrent Hypertrophic Scars/Keloids, 87 were identified through the search strategy, An additional 50 studies referenced outside the “Summary of Literature Review” are included to provide context, but unless they are also cited within the “Summary of Literature Review” they were not used by the committee to guide recommendations. Of the 87 references used as evidence, 86 are categorized as therapeutic references including 3 well-designed studies (Phase II randomized and Phase III), 23 moderately well- designed studies that account for most common biases (matched cohort and Phase II studies), 50 studies with design limitations (retrospective reviews), 4 supplemental studies (not useful as primary evidence), and 7 references that are meta-analysis studies.

ARS Appropriateness Criteria Evidence Table Key: Study Quality Category Definitions

- Category 1* The study is well-designed and accounts for common biases.
- Category 2* The study is moderately well-designed and accounts for most common biases.
- Category 3* There are important study design limitations.
- Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
 - a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
 - b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
 - c) the study is an expert opinion or consensus document.
- Category M* The study is a meta-analysis and has not been rated for quality because the method is designed to evaluate individual studies only.