Clinical experience with hadron therapy at the Heidelberg Ion Beam Therapy Centre
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Embedded in the clinical environment

- fully integrated into the clinical environment and workflow
- surrounded by an academic environment promoting research
- compact size requiring 60 m x 70 m ground surface
Heidelberg Ion-Beam Therapy Center (HIT)

**Ion Sources:**
- Protons
- Carbon
- Helium
- Oxygen

**Gantry:**
360° rotating ion beam

**Position control**

**Treatment rooms**

**Synchrotron**

**Experimental Space**

**Linac**

**Treatment room gantry**
HIT is the world’s first heavy ion treatment facility with a 360° rotating beam delivery system (gantry).
Patients @ HIT

---|---|---|---|---|---|---|---|---|---|---
14 | 214 | 435 | 570 | 637 | 676 | 723 | 690 | 628 | 668 | 189

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Main tumor entities treated at HIT

- Chordoma
- Chondrosarcoma
- Cancers of the Head & Neck / Salivary gland tumors
- Glioma
- Meningioma, AKN
- Pediatric tumors (e.g. CNS, Sarcoma, Craniopharyngeoma)
- Prostate Cancer
- Lung cancer (Pancoast-tumors)
- Lymphoma in young patients / anterior mediastinum
Clinical trials @ HIT

Recruiting Trials:
- ACCO (Photon + C12 boost vs. C12 only in ACC) (24/314)
- PROMETHEUS (C12 for HCC) (20/28)
- INKA (neoadj. C12 in inop. Superior sulcus tumors) (18/20)
- SB-Chordoma (H1 vs. C12) (139/344)
- ISAC (H1 vs. C12 in sacral chordoma) (73/100)
- SB-Chondrosarcoma (H1 vs. C12) (90/154)
- PAROS (Photons vs. H1 for Prostate bed) (84/897)
- CARE (Photons vs. C12 recurrent H&N carcinoma) (1/70)
- PACK (C12 in inop. Pancreatic cancer) (5/25)
- RETRO-ION (neoadj. H1 vs. C12 in soft tissue sarcoma) (8/29)

Completed Trials:
- COSMIC (C12 Boost in Salivary gland tumors) Published
- IMRT HIT-SNT (C12 Boost in sinunasal tumors) (36/36)
- CINDERELLA (C12 for recurrent GBM) (56/56)
- CLEOPATRA (H1 vs. C12 Boost in primary GBM) (97/97)
- APROVE (adj. H1 in cervikal & endometrial cancer) (25/25)
- PROLOG (H1 in recurrent prostate cancer) (70/70)
- KOLOG (C12 in recurrent prostate cancer) (40/40)

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Salivary gland tumors / Adenoid cystic carcinoma

C12 pilot project, patients treated before 2009, mainly T4 (R1/2 or inoperable)
- 58 patients treated with C12 at the GSI (18 GyE C12 + 54 Gy Photons)
- 37 patients treated with photons (66 Gy)
  ➢ Significantly **higher LC in the C12 group**

Original Article

Combined intensity-modulated radiotherapy plus raster-scanned carbon ion boost for advanced adenoid cystic carcinoma of the head and neck results in superior locoregional control and overall survival

Alexandra D. Jensen MD, MSc ☐, Anna V. Nikoghosyan MD,
Melanie Poulakis DDS, Angelika Höss MSc, Thomas Haberer PhD,
Oliver Jäkel PhD, Marc W Münter MD, Daniela Schulz-Ertner MD,
Peter E. Huber MD, PhD, Jürgen Debus MD, PhD

First published: 4 June 2015  Full publication history
DOI: 10.1002/cncr.29443 View/save citation
Cited by: 0 articles  Check for new citations
COSMIC-Trial

COMbined therapy of malignant Salivary gland tuMors with IMRT and Carbon ions

- Phase II feasibility study, dose escalation (18 GyE to 24 GyE C12 boost)
  - 54 patients treated at HIT from 2010 to 2011, 89% ACC
  - No dose limiting acute toxicity
  - Late Toxicity > CTC°2 : < 5%

LC after 3 years: 82 %

Pre-treatment  Treatment planning  C-12 boost  6 weeks post RT

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Adenoid Cystic carcinoma and C12 Only

- In the COSMIC-Trial, local relapse was predominantly in field (79%)
- Will a dose escalation to the primary tumor via C12-only radiotherapy reduce local relapse rate?
- N = 314

**ACC of H&N**
Non-resectable / R1 / R2
N0, M0 (excl. PUL <1cm)

**C12 + IMRT**
BP: 8 x 3 GyE C12
PP: 25 x 2 Gy IMRT

**C12 Only**
BP: 5 x 3 GyE C12
PP: 17 x 3 GyE C12
Re-Radiotherapy in the head & neck region

- 229 patients with recurrent HNC received C12 Re-RT between 2010 and 2017
- 51 Gy RBE in 17 x 3 GyE

HSNCC:
- mOS (C12): 13.7 months
- mOS (Nivolumab): 7.5 months
- mOS (RTOG 9911): 12.1 months
- mOS (RTOG 9610): 8.8 months

Unexpected late toxicity ≥°3: 11.3 %
- Compared to 30% - 40% after photon Re-RT

(Takiar et al., Int J Radiat Oncol Biol Phys, 95 (2016))


Held T1, Windisch P1, Akbaba S1, Lang K1, El Shafie R1, Bernhardt D1, Plinkert P2, Kargus S3, Rieken S4, Herfarth K4, Debus J4, Adeberg S5.

Chondrosarcoma of the skull base

- Rare bone tumors, 5-12% are localized at the skull base
- Resection is often incomplete due to localisation
- G1-G2 tumors are relatively radioresistant, rarely metastatic disease
- Symptoms: cranial nerve deficits (most commonly double vision)


High control rate in patients with chondrosarcoma of the skull base after carbon ion therapy: first report of long-term results.

Uhl M¹, Mattke M, Welzel T, Oellmann J, Habl G, Jensen AD, Eillerbrock M, Haberer T, Herfarth KK, Debus

- 79 pat. after biopsy/ incomplete resection (R2)
- Median follow-up 91 months
- C12 treatment @ GSI 60 GyE in 3 GyE/fx
- 10 yrs LC: 88%
- 10 yrs LC (<45 J): 98%
Chondrosarcoma of the skull base

2005  2007  2011  2015
18y old patient with petroclival chondrosarcoma

before RT

6 weeks after RT
Prospective Pilot-Trial to determine the safety and feasibility of C12 RT in patients with Pancoast-tumors within a trimodal treatment approach

- 18/20 patients recruited
- Excellent metabolic & histopathological response
- No ≥ CTC°3 toxicity
Before treatment

Before surgery / after RCHT

CT-scan

No residual tumor cells in resected tissue (Junker III)

PET/CT-scan

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Mediastinal Lymphomas

• Young patients
• High incidence of secondary malignancies after radiotherapy

• Assumption: risk of secondary cancer correlates with dose to healthy surrounding tissue:
  • incidence of 35% to develop breast cancer at age 50.¹
  • incidence of 49% to develop any kind of secondary malignancy 40 years after mediastinal radiotherapy.²

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Pediatric patients

- Reduced integral dose to non target regions
- Dose escalation at the target volume
- Reduced risk of secondary malignancies / late side effects
Summary

Hadron therapy allows...

... local dose escalation in resistant tumors

... overcome resistance to radiotherapy in some tumors

... local dose escalation in pre-treated patients

... dose sparing to healthy surrounding tissue
Thank you for your attention.