Neuropsychological Outcomes of Children Under Three Treated with Proton Radiation Therapy

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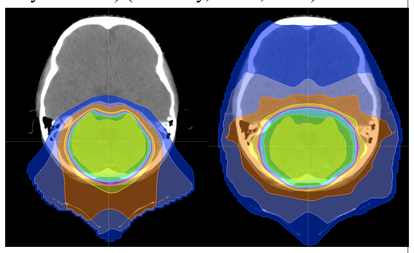
Introduction

- Over 4,000 children are diagnosed with a brain tumor (BT) annually in the US (American Cancer Society, 2020)
- 8-20% of brain tumors occur in children <3 years of age (Ávila de Espíndola, et. al., 2007)
- Radiation is integral to treatment, yet young children fare poorly following photon radiation (XRT), which is the conventional method of treating brain tumors. XRT destroys healthy tissue surrounding the brain tumor, leading to negative cognitive and developmental outcomes.
- Young children are at greatest risk because their brains are rapidly developing; therefore, it is crucial to minimize exposure of radiation to healthy tissue.
- The results of one study found that the average IQ for children under 3 treated with photon radiation was 86.6, while children treated with proton radiation had an average IQ of 98.0 (≥1 year post-BL, $M_{interval}$=5.4 years XRT, $M_{interval}$=2.7 years PRT) (Kahalley, et. al., 2016).

- Proton radiation (PRT) enables better targeting of tumors because it spares the surrounding areas.

Purpose: (1) Intelligence (IQ) and adaptive functioning were examined longitudinally and
(2) Expressive and receptive vocabulary, parent-reported functional communication, visuomotor integration and fine motor skills were examined cross-sectionally in a cohort of children <3 treated with PRT.



PRT (left) affects a smaller portion of the brain than photon radiation (right).

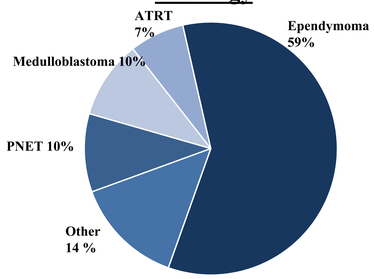
Methods

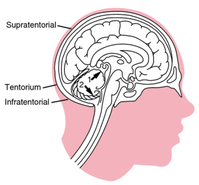
Participants:

- 29 patients received PRT for BT at MGH.
- All patients, ages <3 were evaluated at baseline (BL) during PRT initiation.
- Patients were administered age-appropriate measures of IQ at BL and FU ≥1 year post-BL ($M_{interval}$=2.66 years).

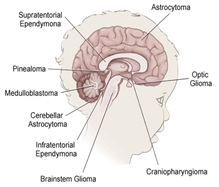
Demographics	
	Mean (± SD) or N (%)
Age at BL	1.99 (0.65)
Age at FU	4.65 (2.33)
Time-Interval (BL-FU)	2.6 (2.1)
Male (N=12)	41.4%
Female (N=17)	58.6%
Race	
Caucasian (N=29)	100%
Location of Tumor	
Infratentorial (N=22)	75.9%
Supratentorial (N=7)	24.1%
Hydrocephalus (N=15)	51.7%
Shunt Placement (N=8)	27.6%
Extent of Radiation	
Partial Brain (N=27)	93.1%
Whole Brain (N=2)	6.9%

Histology

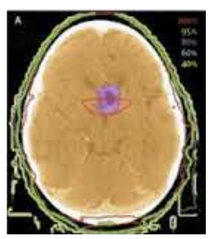




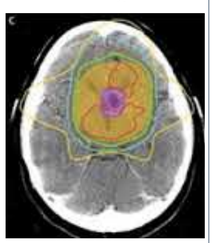
Infratentorial vs. Supratentorial



Location of Different Types of Tumors



Whole Brain Irradiation



Partial Brain Irradiation

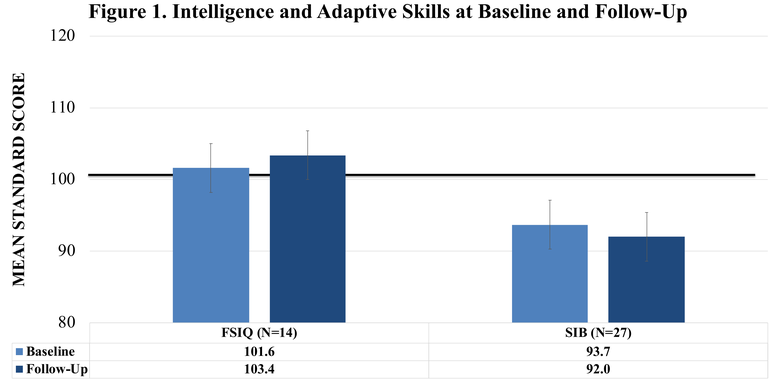
Methods, cont.

Domain	Measure
Intelligence	• Bayley Scales of Infant Development- 2nd Edition (Bayley-2) • Wechsler Preschool and Primary Scales of Intelligence- 3rd Edition (WPPSI-III) • Wechsler Intelligence Scale for Children- 4th & 5th Editions (WISC- IV & V)
Emotional & Behavioral	• Behavior Assessment System for Children- Parent Form: Second Edition (BASC-2)
Adaptive	• Scales of Independent Behavior-R (SIB-R)
Vocabulary	• Expressive One-Word Picture Vocabulary Test- 4th Edition (EOWPVT-4) • Peabody Picture Vocabulary Test- 4th Edition (PPVT-4)
Motor	• Developmental Test of Visuomotor Integration (VMI) • Purdue Pegboard Test

Statistical Analyses: Descriptive Statistics, Paired T-Test, Independent T-Test, & One-Way Analysis of Variance (ANOVA)

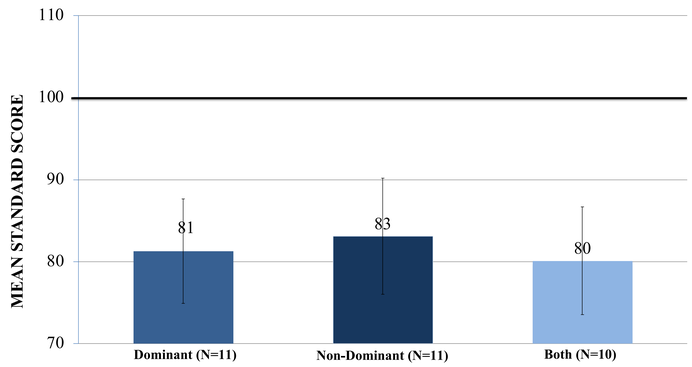
Results

Figure 1. Intelligence and Adaptive Skills at Baseline and Follow-Up



- A paired samples t-test was run to compare intelligence and adaptive behavior scores from baseline to follow-up.
- There was not a significant change in the scores for IQ from baseline (M= 101.6, SD= 16.3) to follow-up (M= 103.4, SD= 17.7); $t(13)$= -.28, p= .78.
- There was not a significant change in overall adaptive behavior from baseline (M= 93.7, SD= 17.7) to follow-up (M= 92, SD= 22.2); $t(26)$= .46, p= .65.
- Mean intelligence and adaptive behavior scores were in the average range at BL and FU.

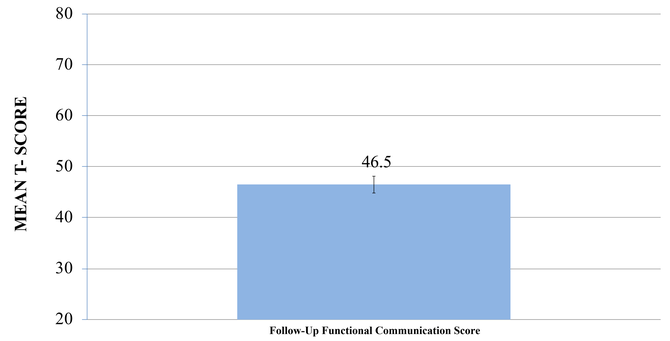
Figure 2. Fine Motor Speed and Dexterity at Follow-Up



- A one-sample t-test was run to analyze scores of motor skills in the sample at FU. The scores of this sample were compared to the motor skills scores of healthy, same-aged peers.
- At FU, compared to same-aged peers, motor skills were significantly lower for dominant (M= 81.3, SD= 21.2); $t(10)$= -2.9, p= 0.015, non-dominant (M= 83.1, SD= 23.5); $t(10)$= -2.39, p= 0.04, and both hands (M= 80.1, SD= 20.8); $t(9)$= -3.02, p= 0.014, scores.

Results, cont.

Figure 3. Functional Communication Skills at Follow-Up



- A one sample-test was run to analyze scores of functional communication from the BASC in the sample at FU.
- The scores of this sample were compared to the functional communication scores of healthy, same-aged peers.
- At FU, functional communication was significantly lower than same-aged peers, (M= 46.5, SD= 8.23); $t(24)$= -2.1, p= 0.045.

Conclusion

- Children who received PRT under the age of 3 showed stable IQ and adaptive functioning skills 2.5 years after treatment
- These scores show a favorable outcome of PRT over XRT.
- At FU, cognitive skills, including IQ and receptive vocabulary, were in the average range, or higher compared to same-aged, healthy peers.
- Results support the literature that PRT leads to better functioning outcomes than photon radiation therapy. In one study, the average IQ for children treated with PRT was 98.0 (Kahalley, et. al., 2016).
- The average IQ of this sample was 101.6 at BL and 103.4 at FL, supporting the claim that the children treated with PRT have higher IQ results than children treated with XRT (Kahalley, et. al., 2016).
- Reduced motor and functional communication skills compared to same-aged peers suggest the need for early intervention.
- In young children, PRT may reduce negative neurocognitive outcomes that are associated with XRT.

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