

Total Arc Degree

* . † . † . *

_____ : _____ arc _____ total arc degree (TAD) .

_____ : XKnife-3 planning system

12, 20, 30, 40, 50 60 mm

TAD 100, 200, 300, 400, 500, 600 , arc 30 (6-arc system) 45 (4-arc system)

50% (V₅₀) (integral biologically effective dose)

_____ : TAD V₅₀ arc 가 30 TAD가 가

가 가 , 45 arc 가 400 TAD 가 400 TAD V₅₀

가 가 . arc 30 TAD가 가

40 mm TAD가 가 , 50 mm 60

mm TAD가 400 가 500 TAD 가 .

_____ : 400 TAD 300 500 TAD

_____ : _____ , Total arc degree,

(therapeutic ratio)

_____ , 1950
(stereotactic radiosurgery)^{1, 6)}

(fractionated stereotactic radio-
therapy)^{7, 8)} 가 .

_____ , arc _____ total arc

_____ 가 _____ degree (TAD)

(critical organ)가

TAD

2000 11 23 2001 4 12

_____ : _____
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3 mm ,
 5 mm
 XKnife-3
 planning system (Radionics®, USA)
 가
 4MV 가
 12, 20, 30, 40, 50, 60 mm
 TAD 100, 200, 300, 400, 500, 600
 arc 30 45
 arc
 30 couch 가 0, 30,
 60, 90, 120, 150 가 6 arc , 45
 couch 가 0, 45, 90, 135 가 4 arc
 weighting

2 Gy , 25
 50 Gy
 , arc TAD
 50% (V₅₀)
 (integral biologically effective dose)
 10%
 histogram) (differential dose-volume 50%
 (V₅₀)
 (linear-quadratic (biologically effective dose)
 Clark Souhami

11 , 10% (d_i)
 (v_i)
 , /

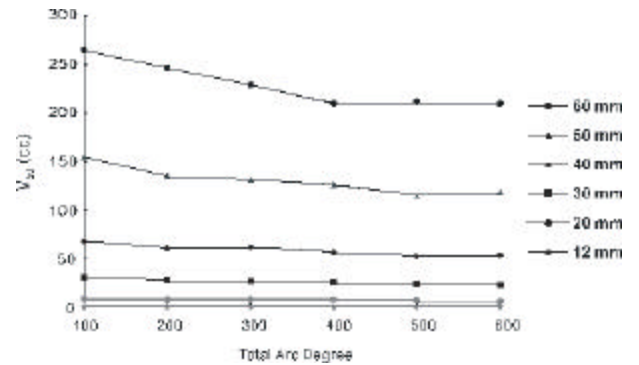
3 .

$$= \sum_i n d_i \left(1 + \frac{d_i}{l} \right) \cdot \frac{v_i}{V}$$

(n=) (V=)

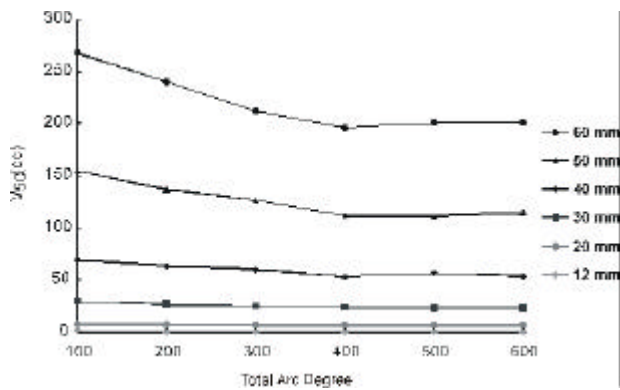
TAD, arc , 가 72
 50% (V₅₀) ,
 V₅₀ arc 가 30 (6-arc system)
 TAD가 가 (Fig. 1).
 arc 가 45 (4-arc system)
 TAD가 가 400
 V₅₀ 가 500 TAD 가
 가 (Fig. 2). 6-arc system 4-arc system
 TAD
 V₅₀ 6-arc system 4-arc system
 30 arc (6-arc system)
 TAD가 가

(Fig. 3). 45 arc



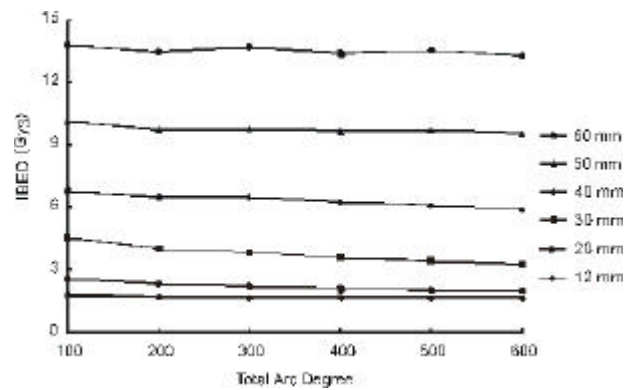
| Collimator Diameter | Total Arc Degree | | | | | |
|---------------------|------------------|-------|-------|-------|-------|-------|
| | 100 | 200 | 300 | 400 | 500 | 600 |
| 12 mm | 1.35 | 1.32 | 1.30 | 1.28 | 1.30 | 1.28 |
| 20 mm | 8.70 | 8.02 | 7.90 | 7.65 | 6.66 | 5.88 |
| 30 mm | 30.9 | 28.1 | 27.0 | 25.3 | 24.3 | 22.3 |
| 40 mm | 68.7 | 61.2 | 62.0 | 56.8 | 52.8 | 54.4 |
| 50 mm | 155.1 | 135.5 | 131.5 | 127.0 | 115.1 | 118.2 |
| 60 mm | 264.9 | 247.1 | 229.2 | 210.0 | 212.5 | 210.6 |

Fig. 1. The volume of normal brain that is delivered high dose radiation [V₅₀ (cc)] according to various collimator diameter in 30 degree arc interval.



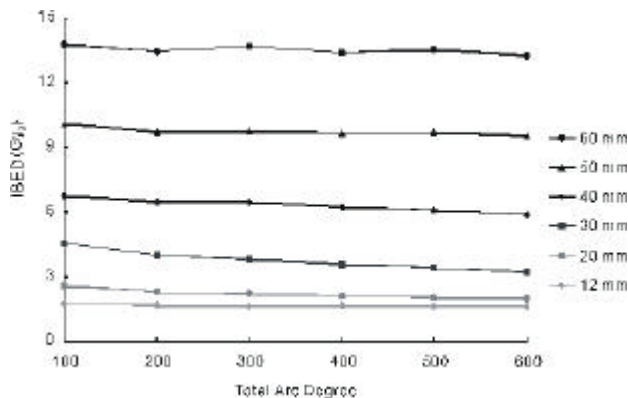
| Collimator Diameter | Total Arc Degree | | | | | |
|---------------------|------------------|-------|-------|-------|-------|-------|
| | 100 | 200 | 300 | 400 | 500 | 600 |
| 12 mm | 1.97 | 1.39 | 1.17 | 1.21 | 1.25 | 1.38 |
| 20 mm | 8.10 | 7.36 | 7.12 | 6.30 | 6.35 | 6.90 |
| 30 mm | 30.0 | 27.1 | 25.4 | 24.0 | 23.7 | 23.5 |
| 40 mm | 70.0 | 64.2 | 60.0 | 52.8 | 57.0 | 53.8 |
| 50 mm | 154.5 | 137.0 | 126.3 | 112.7 | 111.1 | 115.3 |
| 60 mm | 268.0 | 240.1 | 212.2 | 196.0 | 201.5 | 201.0 |

Fig. 2. The volume of normal brain that is delivered high dose radiation [V₅₀ (cc)] according to various collimator diameter in 45 degree arc interval



| Collimator Diameter | Total Arc Degree | | | | | |
|---------------------|------------------|-------|-------|-------|-------|-------|
| | 100 | 200 | 300 | 400 | 500 | 600 |
| 12 mm | 1.82 | 1.70 | 1.66 | 1.64 | 1.64 | 1.66 |
| 20 mm | 2.68 | 2.49 | 2.17 | 2.04 | 2.00 | 2.00 |
| 30 mm | 4.30 | 4.01 | 3.62 | 3.49 | 3.26 | 3.26 |
| 40 mm | 6.86 | 6.47 | 6.32 | 5.92 | 6.01 | 5.79 |
| 50 mm | 10.32 | 9.96 | 9.91 | 9.56 | 9.55 | 9.84 |
| 60 mm | 14.12 | 13.68 | 13.45 | 13.29 | 13.53 | 14.09 |

Fig. 4. Integral biologically effective dose (Gy₃) according to various collimator diameter in 45 degree arc interval.



| Collimator Diameter | Total Arc Degree | | | | | |
|---------------------|------------------|-------|-------|-------|-------|-------|
| | 100 | 200 | 300 | 400 | 500 | 600 |
| 12 mm | 1.78 | 1.68 | 1.66 | 1.67 | 1.66 | 1.63 |
| 20 mm | 2.57 | 2.34 | 2.22 | 2.12 | 2.05 | 1.98 |
| 30 mm | 4.55 | 4.02 | 3.84 | 3.58 | 3.41 | 3.26 |
| 40 mm | 6.78 | 6.47 | 6.47 | 6.23 | 6.10 | 5.88 |
| 50 mm | 10.11 | 9.74 | 9.78 | 9.69 | 9.71 | 9.53 |
| 60 mm | 13.78 | 13.47 | 13.71 | 13.40 | 13.53 | 13.26 |

Fig. 3. Integral biologically effective dose (Gy₃) according to various collimator diameter in 30 degree arc interval.

(4-arc system) 40 mm
 TAD가 가
 50 mm 60 mm
 400 TAD
 가 가 가 500 TAD
 가 (Fig. 4).
 6-arc system 4-arc system

Graham 10)
 10 55 mm 3

3 :

6 , 1, 2, 3, 5, 9 arc 3 mm 25 mm arc

TAD arc 359 , 2 arc TAD NTCP 90 180 TAD

arc 120 . arc 15 mm 140 , 25 mm

(90%) 50% . NTCP , 15

3 arc (TAD 360) 가 mm 9 arc NTCP

가 , 5 arc . Colombo NTCP가 가

3 arc . , , NTCP

20 mm 6 , NTCP

3 가 , 72 NTCP

50% , V_{50} 30 arc (V₅₀) , NTCP 1% , TAD

TAD가 가 . NTCP

, 45 arc 400 TAD volume factor (n) 0.25 (volume effect)

가 400 가 가 TAD NTCP

. arc 30 6-arc system 가 , TAD NTCP

45 4-arc system V₅₀ , NTCP

, 4 arc 400 TAD .

. NTCP

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가 가 , (brain stem)

가 . effective threshold dose 2.5 Gy

60 Gy .

Kutcher ¹¹⁾ Emami ¹²⁾ 가 6% 28% ,

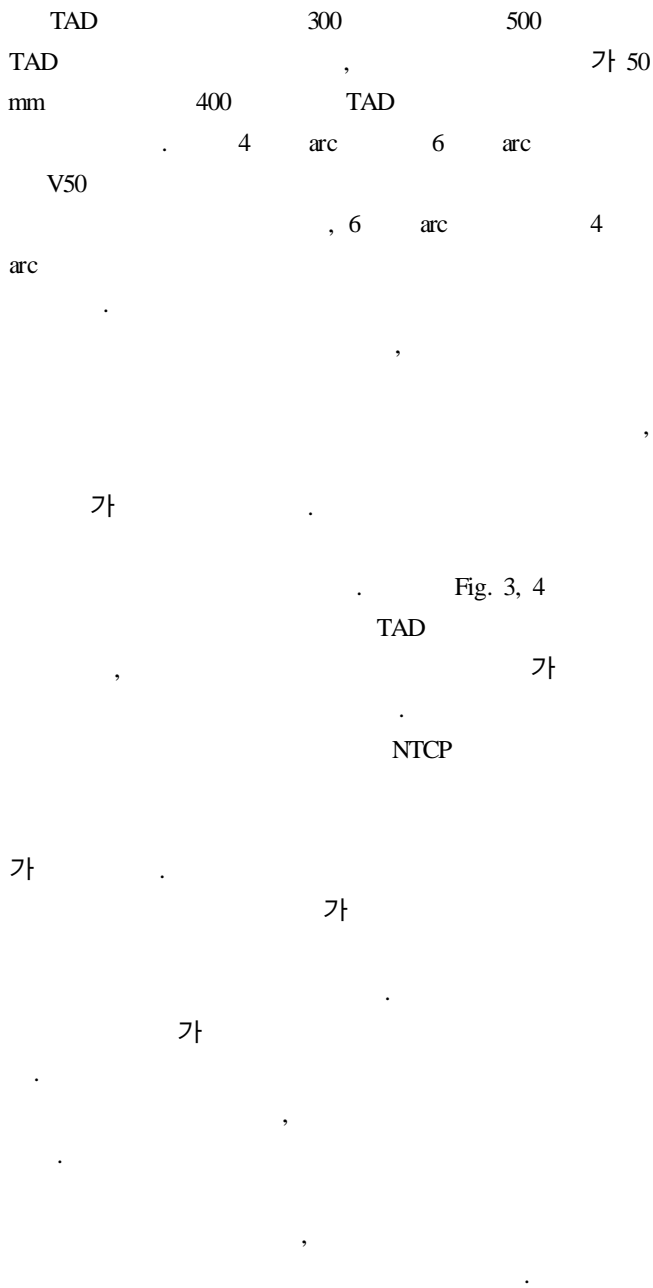
(normal tissue complica- , Niemierko, Lyman NTCP

Kutcher V₅₀

NTCP 가 .¹³⁻¹⁶⁾ Colombo , arc

NTCP 가 TAD ,

NTCP .¹⁷⁾ Colombo , 15 arc 400



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Abstract

Optimization of Total Arc Degree for Stereotactic Radiotherapy by Using Integral Biologically Effective Dose and Irradiated Volume

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Purpose : To find the optimal values of total arc degree to protect the normal brain tissue from high dose radiation in stereotactic radiotherapy planning

Methods and Materials : With Xknife-3 planning system & 4 MV linear accelerator, the authors planned under various values of parameters. One isocenter, 12, 20, 30, 40, 50, and 60 mm of collimator diameters, 100°, 200°, 300°, 400°, 500°, 600° of total arc degrees, and 30° or 45° of arc intervals were used. After the completion of planning, the plans were compared each other using V₅₀ (the volume of normal brain that is delivered high dose radiation) and integral biologically effective dose.

Results : At 30° of arc interval, the values of V₅₀ had the decreased pattern with the increase of total arc degree in any collimator diameter. At 45° arc interval, up to 400° of total arc degree, the values of V₅₀ decreased with the increase of total arc degree, but at 500° and 600° of total arc degrees, the values increased. At 30° of arc interval, integral biologically effective dose showed the decreased pattern with the increase of total arc degree in any collimator diameter. At 45° arc interval with less than 40 mm collimator diameter, the integral biologically effective dose decreased with the increase of total arc degree, but with 50 and 60 mm of collimator diameters, up to 400° of total arc degree, integral biologically effective dose decreased with the increase of total arc degree, but at 500° and 600° of total arc degrees, the values increased.

Conclusion : In the stereotactic radiotherapy planning for brain lesions, planning with 400° of total arc degree is optimal. Especially, when the larger collimator more than 50 mm diameter should be used, the uses of 500° and 600° of total arc degrees make the increase of V₅₀ and integral biologically effective dose. Therefore stereotactic radiotherapy planning using 400° of total arc degree can increase the therapeutic ratio and produce the effective outcome in the management of personal and mechanical sources in radiotherapy department.

Key Words : Stereotactic radiotherapy, Total arc degree, Integral biologically effective dose