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3-Dimensional Conformal Radiation Therapy in Carcinoma of The Nasopharynx

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Purpose : This study was designed to demonstrate the potential therapeutic advantage of 3-dimensional (3-D) treatment planning over the conventional 2-dimensional (2-D) approach in patients with carcinoma of the nasopharynx.

Materials and Methods : The two techniques were compared both qualitatively and quantitatively for the boost portion of the treatment (19.8 Gy of a total 70.2 Gy treatment schedule) in patient with T4. The comparisons between 2-D and 3-D plans were made using dose statistics, dose-volume histogram, tumor control probabilities, and normal tissue complication probabilities.

Results : The 3-D treatment planning improved the dose homogeneity in the planning target volume. In addition, it caused the mean dose of the planning target volume to increase by 15.2% over 2-D planning. The mean dose to normal structures such as the temporal lobe, brain stem, parotid gland, and temporomandibular joint was reduced with the 3-D plan. The probability of tumor control was increased by 6% with 3-D treatment planning compared to the 2-D planning, while the probability of normal tissue complication was reduced.

Conclusion : This study demonstrated the potential advantage of increasing the tumor control by using 3-D planning, but prospective studies are required to define the true clinical benefit.

Key Words : Three-dimensional conformal radiation therapy, Nasopharyngeal carcinoma

1996

1998 8 5

1998 9 28

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T N

T3-4, N0-N1
 (local recurrence) 50% , N2-N3
 가
 T 1.

T2 60Gy 70Gy 가 가
 76% 94% 가
¹⁾ Valentine T3 T4 가 70 (Aquaplast
 Gy 가 가[®])
²⁾ 가 5mm 46
 가 (myelitis), DAT(digital audio tape)
 (xerostomia), (trismus), Pinnacle[®]
 (osteoradionecrosis), (brain necrosis)
 가
 (Computed Tomogram) (target volume)
 (Magnetic Resonance Imaging) 1.5cm
 (planning target volume; PTV)
 3
 (3-Dimensional radiation treatment manual mode contou-
 planning system)가 3 ring 2
 (3-Dimensional conformal radiotherapy)가 가 (parallel-opposed
 2 two lateral ports) 90 , 270
 (conventional plan; 2-D) 3 (digitally
 (3-Dimensional conformal radiation treatment reconstructed radiograph; DRR)
 plan; 3-D) 3 3
 가 (beam
 direction) (beam's eye
 view; BEV)
 dose escalation study가³⁾ 4-6)
 non-coplanar
 (Fig. 1), back projection
 3 non-
 coplanar 5 (ports) 3
 2 3
 3 70.2Gy
 2
 50.4 Gy 가 2
 (2-D plan) 3 (3-D plan)

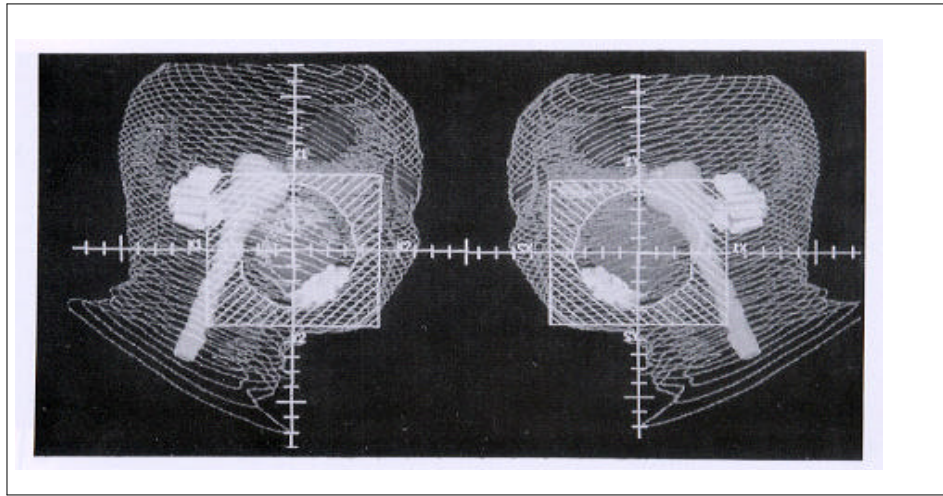


Fig. 1. Beam's eye view.

1. $D_{50}, D_0, V_{95},$
- 2.
- 3.
4. (numerical scoring)
 - (dose volume histogram; DVH)
 - (tumor control probability; TCP)
 - (normal tissue complication probability; NTCP)
 - DVH
 - NTCP TCP
 - n, m Burman⁷⁾
 - , TCP
 - normalized gamma
 - 1, 2)

$$P(D) = 0.5^{\exp\{2.9 \times \gamma_{50}(1-D/D_{50})\}} \quad (1)$$

TCD₅₀ 50%

Lyman

Table 1. Tumor Control Probability(TCP) Parameters

| Stage | Prescribed Dose(Gy) | TCP at Prescribed Dose(Gy) | at TCP=50% |
|-------|---------------------|----------------------------|------------|
| T1/T2 | 70 | 85 | 2.5 |
| T3/T4 | 70 | 50 | 1.0 |

Table 2. Normal Tissue Complication Probability parameters

| organ | TD50(Gy) | n | m | Endpoint |
|---------------|----------|------|-------|--------------------|
| spinal cord | 65 | 0.05 | 0.175 | Myelitis |
| Braintem | 65 | 0.16 | 0.14 | Necrosis |
| Temporal lobe | 60 | 0.25 | 0.15 | Necrosis |
| TM joints | 72 | 0.07 | 0.10 | Limit of joint fc. |
| Parotid | 46 | 0.70 | 0.18 | Xerostomia |
| Optic chiasm | 65 | 0.25 | 0.14 | Blindness |
| Optic nerve | 65 | 0.25 | 0.14 | Blindness |

50 TCD₅₀

$$TCP = [P(D)]^{p \cdot V_{\text{voxel}}} \quad (2)$$

N, Di i

(2)

$$TCP = \exp \{ \rho * V_{\text{voxel}} * \sum \ln[P(D)] \}$$

Table 3. Dose and Volume Statistics for Planning Target Volume Comparing 2D Plan and 3D Plan

| | Dmin(%) | Dmax(%) | Dmean(%) | D95(%) | D05(%) | V95(%) |
|---------|---------|---------|----------|--------|--------|--------|
| 2D plan | 71.6 | 106.7 | 101.5 | 98.7 | 104.0 | 99.6 |
| 3D plan | 100.0 | 119.4 | 116.7 | 114.0 | 118.8 | 100.0 |

Dmin : The percent of minimum dose in planning target volume
 Dmax : The percent of Maximum dose in planning target volume
 Dmean : The percent of mean dose in planning target volume
 D95 : The percent of dose that 95% of the volume receives
 D05 : The percent of minimum dose that volume receives
 V95 : The percent of volume receiving 95% of the prescription

(error function)

$$TD(1) = TD(v)^*v^n$$

$$Deff = [\sum Vi(Di)^{1/n}]^n$$

$$NTCP = 1/\sqrt{2\pi} \int \exp(-t^2/2) dt$$

$$t = [D - TD_{50}(v)] / m * TD_{50}(v)$$

$$v = V/V_{ref}$$

TD (tolerance dose) Deff (effective volume dose)
 TD₅₀(v) 50% (tolerance dose)

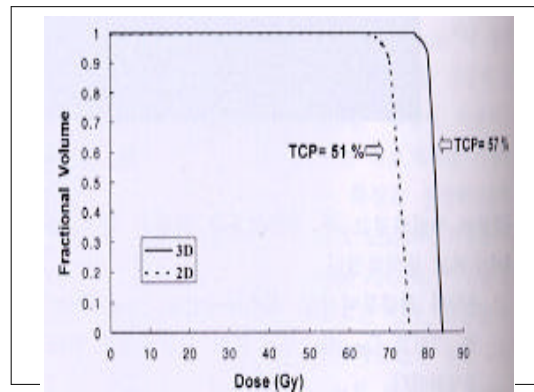


Fig. 2. Comparison of dose volume histogram in planning target volume

1. 1) 가 (51% vs 57%)(Fig. 2).

Table 3 Table 3 2. 가 2. 가 3 95% 가 (Fig. 3). 95% (volume rendering) (Fig. 4).

3 3 2 3 3

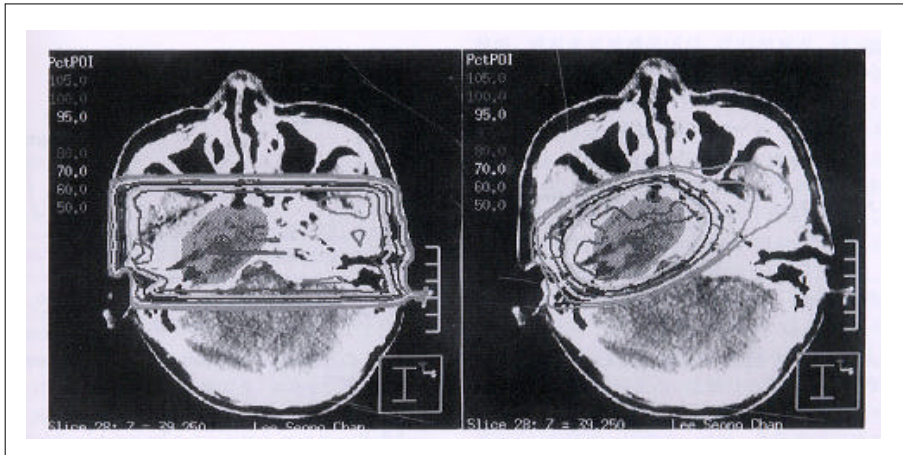


Fig. 3. Display of isodose distribution for conventional 2-D(left) and 3-D(right) conformal treatment plans.

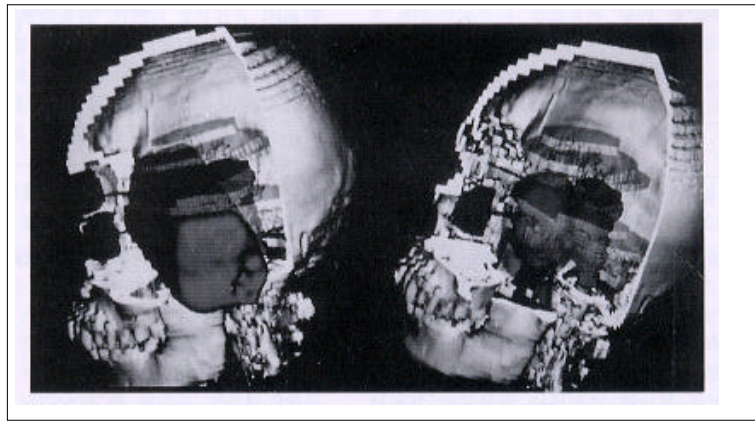


Fig. 4. Display of 95% isodose volume rendering and adjacent normal organs for conventional 2-D(left) and 3-D(right) conformal treatment plans.

가 가
가 가 (Fig. 5).

2)

Fig. 6-9

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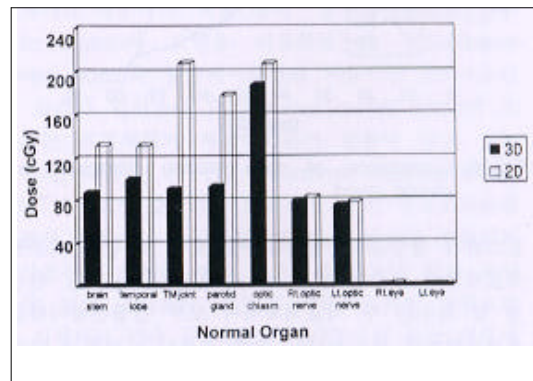


Fig. 5. Comparison of the median dose in adjacent normal organs.

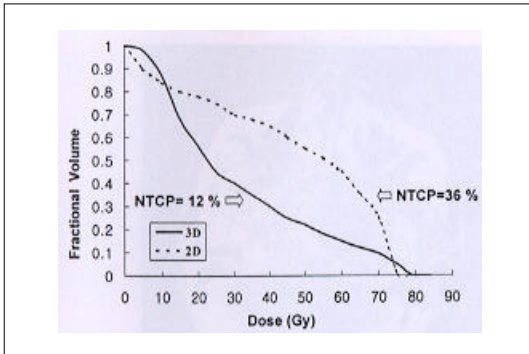


Fig. 6. Comparison of dose volume histogram in brain stem.

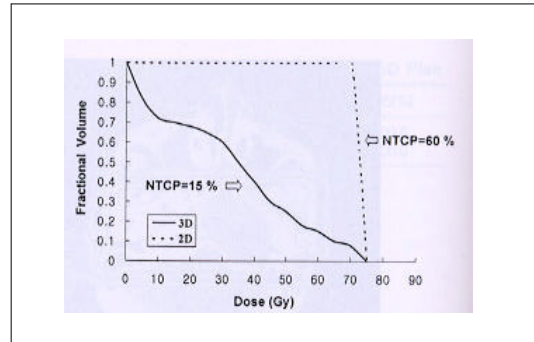


Fig. 9. Comparison of dose volume histogram in T-M joint.

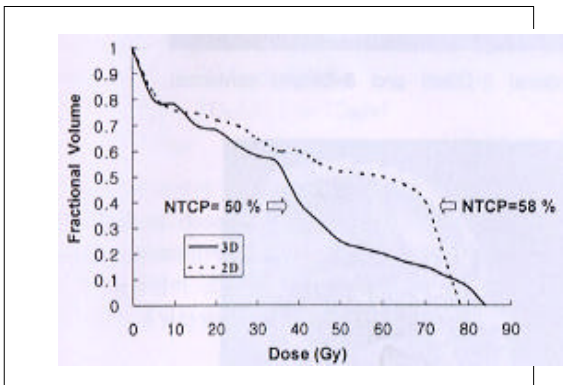


Fig. 7. Comparison of dose volume histogram in temporal lobe.

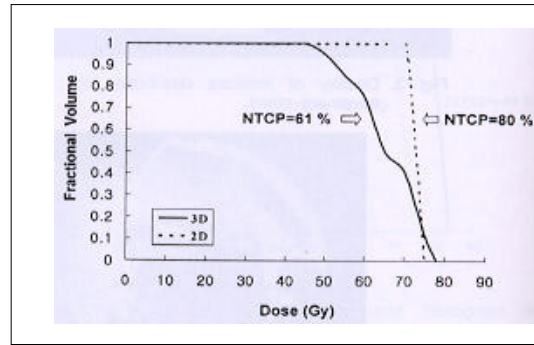


Fig. 10. Comparison of dose volume histogram in optic chiasm.

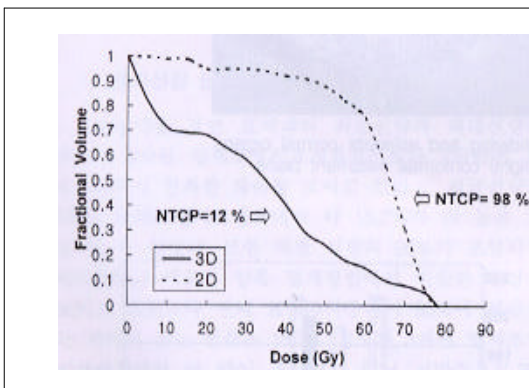


Fig. 8. Comparison of dose volume histogram in parotid gland.

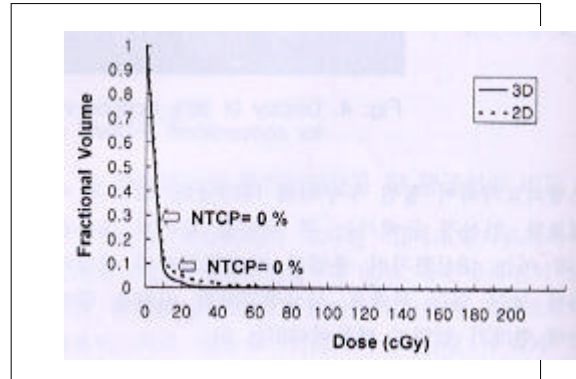


Fig. 11. Comparison of dose volume histogram in spinal cord.

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(Fig. 10).

(Fig. 11,
12).

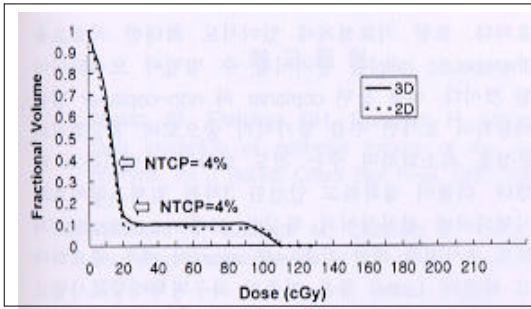
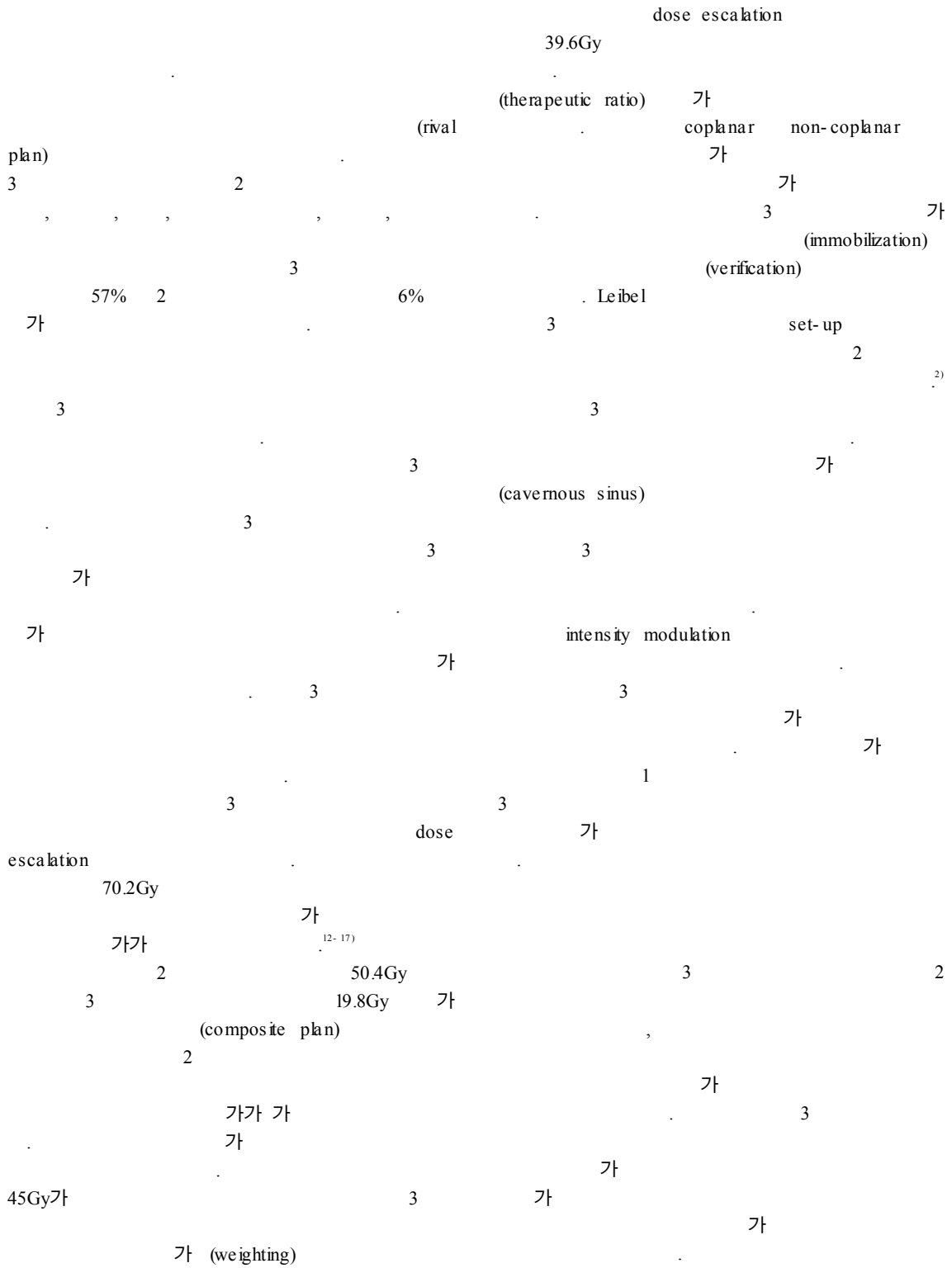


Fig. 12. Comparison of dose volume histogram in optic nerve.

가 3
2 3
3 2
3 50.4Gy 가
가 2 3
3
(underdosed region)
가 가
3 15.2%
2
(isocenter) prescription
3 prescription
(integral dose)
(conformation) Goiten
(cold spot) control dose)
가 TCD₅₀(tumor
(hot spot) (intrinsic radiosensitivity)

^{10, 11)} Leibel BEV
95%
15%
³⁾ 1%
가 (cavernous sinus)
가
가
45Gy 가
3 2
가
가 3 (Fig. 1).
50.4Gy 3 가
3
3 2
3
(parameter)
Goiten TCD₅₀(tumor
control dose) 가 TCD₅₀(tumor control dose)
가 (intrinsic radiosensitivity)



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