ORIGINAL ARTICLE

Outcomes Following Temporalis Tendon Transfer in Irradiated Patients

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Objective: To compare objective outcomes and complications following temporalis tendon transfer in patients with and without a history of radiation to the parotid bed.

Methods: Retrospective medical chart review comparing dynamic movement of the oral commissure and resting symmetry achieved in 7 irradiated patients (group R) and 7 nonirradiated patients (group N) after temporalis tendon transfer for unilateral facial paralysis.

Results: There were no significant differences between the 2 groups of patients in terms of age, additional facial reanimative procedures, baseline lip position, or follow-up time. Postoperatively, good resting symmetry was achieved in both groups. The mean commissure excursion was significantly inferior in the irradiated group of patients (−1.5 mm in group R vs 2.1 mm in group N; $P < .05$). Two patients in the irradiated group experienced surgical site infections requiring hospital admission and eventual debridement of their tendon transfers.

Conclusions: Temporalis tendon transfer seems to produce less dynamic movement in patients who have received radiation to the parotid bed, and these patients may also be at higher risk of postoperative infection. Temporalis tendon transfer can achieve good resting symmetry in both irradiated and nonirradiated patients.

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Facial paralysis has enormous implications that have an impact on daily routines and quality of life. From a functional standpoint, facial paralysis results in paralytic lagophthalmos, ectropion, epiphora, ipsilateral nasal obstruction, and oral incompetence. Even more debilitating is the loss of facial symmetry and emotive expression, which are so integral to daily human communication and interaction. Over the past 4 decades, considerable progress has been made in the surgical interventions for facial paralysis, and we are now able to reliably protect the eye and reanimate the face.

Although attaining static symmetry is an improvement, the ultimate goal is to restore a mimetic smile. Dynamic facial motion requires stimulatory input to functioning musculature. Options for input include the native nerve when available, the contralateral intact facial nerve via cross-facial nerve grafts, or various ipsilateral motor nerves, including the hypoglossal and masseteric nerves. However, chronic denervation leads to facial muscle atrophy. After a critical period, estimated at 18 to 24 months, reinnervation of these atrophic muscles will usually not result in facial movement. In the absence of functional native facial musculature, regional or free muscle transfer is required.[1]

Free muscle transfer most commonly is a 2-stage procedure with initial cross-facial nerve grafting followed by microneurovascular muscle transfer once axons have reached the paralyzed side of the face. This process may take up to 2 years. While the results can be impressive, disadvantages to this technique include technical complexity, prolonged surgery and recovery time, potential facial nerve injury on the unaffected side, and somewhat unpredictable results even in the most experienced hands.[2]

Regional muscle transfer offers a viable alternative in patients who are poor candidates for free tissue transfer or who are unwilling to undergo the more protracted treatment course. The masseter and temporalis muscles have both been used in this capacity. Over the past decade,

Table 1. Patient Characteristics

Patient No./ Age at TTT, y[a]	Duration of Paralysis	Reason for Paralysis	Other Facial Reanimative Surgical Procedures	Hematoma	Major Infection
Group N					
1/81	53 y	Unknown CPA tumor	FA, DT, LLT, SL	No	No
2/74	10 mo	Ramsay-Hunt	BL, FA, DT, LW	No	No
3/67	12 y	Vest schwannoma	FA, LLT, AC, PW, BL, DT, SL	No	No
4/59	12 mo	Vest schwannoma	PW, LLT, LW, AC, SL, DT	No	No
5/55	12 y	Idiopathic	FA, SL, LLT, DT, NVS	Yes	No
6/51	5 y	Facial schwannoma	PW, SL, LLT, AC, LW	No	No
7/41	2 y	Vest schwannoma	PW, LLT, FA, AC, SL, GT	No	No
Group R					
1/54	4 y	Met tonsillar SCCA	FNG, PW, LLT, SL, DT	No	No
2/56	2 y	Parotid MT	SL, BL	No	No
3/50	5 y	Parotid MT	SL, AC, DT, FA, LLT	No	Yes
4/72	14 mo	Met cutaneous SCCA	PW, DT, AC, SL, MNT	No	No
5/66	8 mo	Met cutaneous SCCA	FA, SL, LLT, AC, BL, LW, DT	Yes	No
6/75	3 mo	Parotid MT	FNG, AC, SL, DT, BL, PW	No	No
7/64	5 y	Parotid MT	SL, MNT, NVS, PW, BL, MC	No	Yes

Abbreviations: AC, auricular cartilage to support lower eyelid; BL, direct brow-lift; CPA, cerebellopontine angle; DT, depressor transection; FA, facial advancement; FNG, facial nerve grafting; GT, free gracilis transfer (performed at another institution prior to TTT with poor result); LLT, lower eyelid tightening procedure; LW, lower lip wedge resection; MC, medial canthoplasty; met, metastatic; MNT, marginal nerve transection; MT, malignant tumor; N, nonirradiated; NVS, nasal valve suspension; PW, upper eyelid platinum weight; R, irradiated; SCCA, squamous cell carcinoma; SL, suborbicularis oculi midface-lift; TTT, temporalis tendon transfer; vest, vestibular.

[a] The mean ages for groups N and R are 61.1 years and 62.4 years, respectively.

Labbé and Huault[3] and others have published extensively on orthodromic temporalis tendon transfer (TTT) for dynamic reanimation of the oral commissure. Through careful attention to the anatomy of the tendinous insertion on the mandible and to that of the normal smile, one can achieve impressive dynamic excursion rivaling that obtained with free muscle transfer and cross-facial nerve grafting.

Practice patterns vary, but at our institution facial paralysis is frequently due to primary or metastatic malignant disease in the parotid gland. Typically, these patients receive adjuvant radiation therapy (XRT) for perineural invasion and other high-risk factors. Radiation-induced soft-tissue fibrosis is a phenomenon well known to otolaryngologists caring for patients with head and neck cancer. It has been our experience that patients who have received adjuvant XRT to the parotid bed prior to TTT obtain less dynamic excursion and have an increased incidence of postoperative complications.

The purpose of this study was to compare the objective outcomes achieved following TTT in patients who have and those who have not received radiation to the parotid bed prior to facial reanimation surgery.

METHODS

This study was approved by the University of Michigan Health System institutional review board (No. HUM00029611), and all patients provided written informed consent. We performed a retrospective medical chart review of all patients who underwent TTT in the Department of Otolaryngology–Head and Neck Surgery at the University of Michigan, Ann Arbor. The inclusion criteria were adult patients (>18 years) presenting with unilateral facial paralysis, who received TTT, and who had at least 3 months of follow-up. Exclusion criteria included inadequate photographic documentation, ongoing treatment for residual or recurrent malignant disease, or noncompliance with basic postoperative instructions, such as wound care and administration of antibiotics. The independent variable was XRT to the parotid bed prior to TTT. We also collected data on age, radiation technique and dose received, additional facial reanimation surgical procedures, and hematoma or infection requiring return to the operating room or hospital admission (**Table 1**). Informed written consent was obtained from all patients prior to their inclusion in this study. A separate consent for publication of photographs was obtained from patients whose images appear in this article.

The primary outcome was oral commissure movement preoperatively and at least 3 months postoperatively in the irradiated patients (group R) and nonirradiated patients (group N) who underwent TTT surgery. (Hereinafter, patient numbers refer to their group.) Commissure excursion was calculated from preoperative and postoperative standardized photographs taken during neutral facial expression and closed-mouth smile. The mean time between TTT and postoperative photographic analysis was not statistically different between the 2 groups (group N: mean, 254 days [range, 100-601 days]; group R: mean, 319 days [range, 96-684 days]; $P = .58$). Proprietary facial metrics software (MEEI FaceGram, Massachusetts Eye and Ear Infirmary) was used to calculate the long diagonal or hypotenuse of movement (termed c, measured in millimeters), as well as the angle formed with the vertical (termed A, measured in degrees). This program is described elsewhere[4] and uses the patient's irises to set a vertical midline and to calculate distances, as demonstrated in **Figure 1**. The value Δc was calculated for each side of the face and time point using the formula $\Delta c = c_{smile} - c_{rest}$. ΔA was similarly tabulated as $\Delta A = A_{smile} - A_{rest}$. Resting symmetry was calculated as a secondary outcome by comparing the values of c and A between the intact and paralyzed sides. This was done for both pre-TTT and post-TTT time points, and for both patient groups.

The primary and secondary between-group comparisons were performed using 2-tailed t tests in Microsoft Excel 2010 (Microsoft Corp).

A brief description of our technique for TTT is as follows. Under general anesthesia, an incision is made in the melolabial crease. Blunt finger dissection is performed starting at the modiolus, establishing a plane between the buccinator and buccal fat until the anterior border of the masseter muscle is encountered. The masseter muscle is retracted laterally, exposing the coronoid. The temporalis tendon is left attached to the coronoid process, which is then transected at the base of the mandibular notch using a reciprocating saw. A tensor fascia lata (TFL) graft is harvested from the thigh. Holes are drilled in the coronoid process, and the TFL is sutured to the coronoid process with the attached temporalis tendon with 3-0 polydioxanone (PDS) suture. Medially, the TFL graft is cut such that it is longer inferiorly and shorter superiorly. Through the melolabial incision, dissection between the subcutaneous tissues and superficial facial musculature is performed into the midline lower lip. A separate 15-mm incision is made in the midline submental crease. The TFL graft is tunneled into the lower lip and sutured to the midline orbicularis musculature through the submental incision using 3-0 PDS. The superior part of the TFL is then sutured to the facial muscles just medial to the melolabial crease using the same suture. This is done in a manner such that there is minimal tension on the temporalis muscle at rest. The melolabial and submental incisions are closed in 2 layers. **Figure 2** portrays patient N3 attempting a closed-mouth smile preoperatively and 3 months postoperatively.

Patients receive post-TTT physiotherapy from an affiliated occupational therapist.

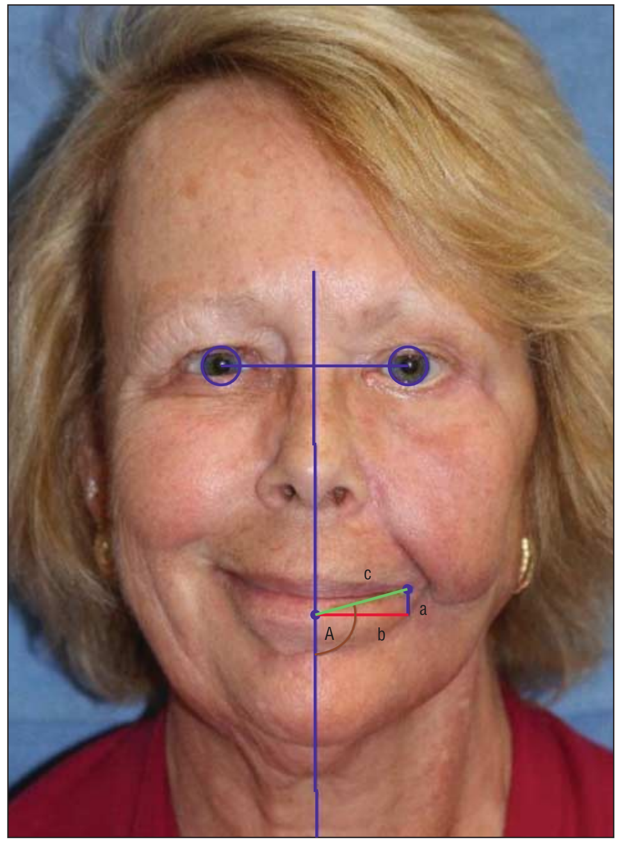

Figure 1. Method of photographic analysis of a patient from the irradiated group (group R). Patient R7 3 months after temporalis tendon transfer. Her pupils have been manually outlined, and the computer program uses this information to drop a vertical midline. The intersection of this line with the vermiliocutaneous border of the lower lip, and the commissure, are then manually identified. This allows the program to draw and calculate values for triangle sides *a*, *b*, and *c* and angle *A*, formed with the vertical. Note that angle *A* measures between *c* and the midline below the lip; thus, "good" values are usually over 105°.

RESULTS

The senior author (J.C.K.) began performing TTT in October 2008 and has performed the procedure in 16 patients since. At the time of writing, all patients had at least 3 months of postsurgical follow-up. Seven patients had not received XRT to the parotid bed (group N). Nine patients had received XRT prior to TTT. Two of the patients in group R died from cancer with inadequate follow-up for inclusion, leaving 7 patients in group R group. All 14 patients included in this study are still alive.

Patient characteristics are summarized in Table 1. The mean ages in the 2 groups were not different ($P = .84$). The types and numbers of additional facial reanimative procedures were similar between the 2 groups. There was 1 hematoma requiring surgical drainage in both groups. Patients R3 and R7 developed infections requiring inpatient admission, parenteral antibiotics, and eventual TFL debridement. There were no serious infections in the nonirradiated group.

We were unable to obtain complete XRT details in all cases because many patients received this treatment at outside institutions, some more than 10 years prior to their TTT. Patient R1 received concomitant cisplatin and 3-dimensional conformal radiotherapy (3D-CRT) with 70 Gy to the left tonsillar fossa and neck. Given her high-dose treatment and the proximity of the tonsil to the masticator space, she was included in the radiated group. Patient R2 received concurrent chemoradiation with 3D-CRT to the parotid bed. Patient R3 received 40 Gy of 3D-CRT, 30-Gy proton beam, and 10-Gy neutron beam XRT to the parotid bed for a malignant parotid tumor. Patient R4 received 60 Gy of 3D-CRT to the left parotid bed and neck. Patient R5 completed a course of XRT for a malignant parotid tumor (unknown technique or dose). Patient R6 received concurrent chemotherapy with 60 Gy of 3D-CRT to the parotid bed. Patient R7 received 60 Gy of 3D-CRT to the parotid bed. No patients in our study received intensity-modulated radiation therapy (IMRT).

Table 2 demonstrates measurements for *c* and *A* at rest and with smile for the intact and paralyzed sides prior to TTT. The *P* values provided in the Table represent a 2-tailed *t* test comparing the means of groups N and R. It is important to note that there was no statistical difference between the 2 groups in Δc or ΔA preoperatively on either the intact or paralyzed sides. This suggests that prior to TTT, perioral movement in the 2 groups was not different.

Table 3 includes these same measurements *after* TTT. Postoperatively, there was no statistical difference in either Δc or ΔA between the 2 groups on the normal side. However, post-TTT oral commissure movement as assessed by both Δc and ΔA was statistically greater in group N (mean $c = 2.1$ mm [range, −1.4 to 6.6 mm]; mean $A = 7.0°$ [range, 0.6°-20.1°]) compared with group R (mean $c = -1.5$ mm [range, −4.3 to 1.8 mm]; mean $A = 0.3°$ [range, −6.1° to 5.0°). Negative values for Δc or ΔA essentially mean that the oral commissure moved *inferiorly* (*A*) or *medi-*

Figure 2. Preoperative and postoperative photographs of patient 3 from the nonirradiated group (group N). Patient N3 attempting a closed-mouth smile preoperatively (A) and 3 months postoperatively (B). She underwent right facial advancement flap, right lower eyelid tightening with auricular cartilage graft to support the eyelid, right upper eyelid platinum weight placement, right suborbicularis oculi midface-lift, right direct brow-lift, and left lower lip depressor transection. We have found that female patients who begin wearing makeup again postoperatively are the patients that are most pleased with their results.

ally (*c*) with smile. This is opposite the desired movement and can occur if the normal side overpowers the paralyzed side during smile.

The secondary outcome, "resting symmetry," was assessed by comparing the means for *c* and *A* between the paralyzed and normal sides for both groups, both preoperatively and postoperatively. This yielded 8 overall comparisons, summarized in **Table 4**. All pre-TTT comparisons in both groups revealed a statistical difference in both *c* and *A*, suggesting *asymmetry* at rest. However, *c* and *A* were not statistically different in either group post-TTT, suggesting that resting symmetry was restored post-TTT.

COMMENT

There are several approaches to dynamic facial reanimation, including nerve grafting, nerve substitution, or muscle substitution. Muscle substitution techniques are typically reserved for those patients with facial paralysis in whom the native facial musculature has either undergone denervation atrophy or fibrosis, or has been destroyed by trauma or tumor ablation.[5] Both regional and free microneurovascular muscle substitution techniques are well described in the literature. Despite many articles describing various methods of measuring objective outcomes following muscle transfer for facial paralysis,[6] relatively few publications have reported objective outcomes data. Erni et al[7] are, to our knowledge, the only group to have directly compared commissure movement obtained after TTT vs free muscle transfer (gracilis, latissimus, or pectoralis minor). In their study, TTT produced 1.8 mm of excursion with closed-mouth smile compared with 9 mm on the healthy side. Free muscle transfer yielded 5.5 mm of excursion compared with 10 mm on the intact side. The difference in excursion between the TTT and free tissue groups was statistically significant. Unfortunately, the authors did not include the raw data, or range of excursion, produced by TTT. Byrne et al[8] reported a range of excursion of 1.6 to 8.5 mm (mean, 4.2 mm) in 7 patients undergoing TTT. Patient details were not included regarding etiology of paralysis or history of radiation to the parotid bed. Labbé and Huault[3] reported up to 15 mm of excursion from their lengthening temporalis myoplasty, a modification of the TTT in which the posterior temporalis muscle belly is released, thereby placing the muscle at a more optimal location on its length-tension curve. Collectively, these studies report commissure excursion after TTT ranging from 1 to 15 mm. Differences in experience and surgical technique may play some role, but other factors contributing to this degree of variability have yet to be identified.

Table 2. Pre-TTT Measurements[a]

	Normal Side						Paralyzed Side					
	At Rest		With Smile				At Rest		With Smile			
Patient	*c*	*A*	*c*	*A*	Δc	ΔA	*c*	*A*	*c*	*A*	Δc	ΔA
Group N												
1	27.9	122.8	36.0	127.1	8.1	4.3	32.4	110.0	31.1	109.8	−1.3	−0.2
2	31.7	104.0	33.6	105.5	1.9	1.5	17.7	88.1	18.0	68.9	0.3	−19.2
3	30.9	108.2	35.7	113.6	4.8	5.4	26.6	100.6	21.8	94.7	−4.8	−5.9
4	32.9	103.6	35.3	105.7	2.4	2.1	17.3	92.1	18.3	88.4	1.0	−3.7
5	30.6	115.2	36.1	121.7	5.5	6.5	31.2	115.1	28.8	128.2	−2.4	13.1
6	24.8	101.3	32.6	116.0	7.8	14.7	18.5	85.9	16.8	90.1	−1.7	4.2
7	35.2	109.5	39.3	114.5	4.1	5.0	16.9	86.5	14.0	86.0	−2.9	−0.5
Mean	30.6	109.2	35.5	114.9	4.9	5.6	22.9	96.9	21.3	95.2	−1.7	−1.7
Group R												
1	24.2	105.9	31.1	117.9	6.9	12	17.3	96.0	15.8	92.1	−1.5	−3.9
2	35.6	110.2	39.0	112.2	3.4	2.0	23.6	94.0	22.0	89.0	−1.6	−5.0
3	31.7	95.9	40.7	103.0	9.0	7.1	23.9	93.3	21.7	80.4	−2.2	−12.9
4	32.4	102.6	40.3	112.0	7.9	9.4	15.5	95.8	17.5	98.3	2.0	2.5
5	PQ[b]	PQ[b]	26.2	104.0	PQ[b]	PQ[b]	PQ[b]	PQ[b]	23.1	68.2	PQ[b]	PQ[b]
6	35.2	112.8	38.9	104.0	3.7	−8.8	19.8	87.2	28.7	78.2	8.9	−9.0
7	22.4	98.6	29.6	113.2	7.2	14.6	25.5	95.7	27.0	90.8	1.5	−4.9
Mean	30.3	104.0	35.1	109.5	6.4	6.1	20.9	93.7	22.3	85.3	1.2	−5.5

Abbreviations: *A*, angle formed with the vertical, measure in degrees; *c*, long diagonal or hypotenuse of movement; N, nonirradiated; R, irradiated; TTT, temporalis tendon transfer.

[a] *P* values for Δc and ΔA for normal side: .31 and .91, respectively; for paralyzed side, .13 and .42, respectively.

[b] Signifies data that could not be obtained due to poor quality (PQ) of preoperative photograph.

Table 3. Post-TTT Measurements

	Normal Side						Paralyzed Side					
	At Rest		With Smile				At Rest		With Smile			
Patient	*c*	*A*	*c*	*A*	Δc	ΔA	*c*	*A*	*c*	*A*	Δc	ΔA
Group N												
1	24.6	117.6	33.6	123.3	9.0	5.7	38.5	110.5	40.3	111.9	1.8	1.4
2	27.4	112.3	31.4	117.7	4.0	5.4	19.3	106.1	25.9	117.6	6.6	11.5
3	26.0	104.7	30.2	109.3	4.2	4.6	31.8	106.3	30.4	106.9	−1.4	0.6
4	27.0	96.5	35.5	114.1	8.5	17.6	28.1	96.3	29.7	116.4	1.6	20.1
5	25.7	117.8	29.0	117.0	3.3	−0.8	29.8	115.0	36.3	120.7	6.5	5.7
6	28.4	110.8	31.2	112.7	2.8	1.9	24.8	102.3	25.9	106.4	1.1	4.1
7	32.3	101.6	36.7	105.1	4.4	3.5	24.5	101.0	23.1	106.3	−1.4	5.3
Mean	27.3	108.8	32.5	114.2	5.2	5.4	28.1	105.4	30.2	112.3	2.1	7.0
Group R												
1	24.8	110.5	28.4	113.1	3.6	2.6	29.4	108.8	31.2	113.6	1.8	4.8
2	36.2	114.6	35.5	117.8	−0.7	3.2	32.6	110.3	28.3	108.5	−4.3	−1.8
3	27.1	96.3	37.5	106.0	10.4	9.7	29.0	107.3	26.1	101.2	−2.9	−6.1
4	31.8	95.8	34.6	103.9	2.8	8.1	19.4	96.8	16.8	98.6	−2.6	1.8
5	25.9	91.0	26.4	95.8	0.5	4.8	25.0	95.6	25.7	100.6	0.7	5.0
6	33.9	105.4	42.2	109.7	8.3	4.3	23.7	92.4	21.9	93.0	−1.8	0.6
7	22.7	101.5	31.0	116.2	8.3	14.7	31.6	108.0	29.8	105.9	−1.8	−2.4
Mean	28.9	102.2	33.7	108.9	4.7	6.8	27.2	102.8	25.7	103.1	−1.5	0.3
P Value					.82	.63					.03	.04

Abbreviations: *A*, angle formed with the vertical, measured in degrees; *c*, long diagonal or hypotenuse of movement; N, nonirradiated; R, irradiated; TTT, temporalis tendon transfer.

Based on personal observations, we hypothesized that at least some of the variability in our own results could be attributed to radiation status. Other publications describing orthodromic TTT have alluded to possibly worse outcomes in irradiated patients.[9] We found that there was statistically less commissure movement in patients who had received XRT to the parotid bed. Also, 2 patients in group R developed clinically significant infections of their TFL grafts, requiring parenteral antibiotics and eventual TFL debridement. No patients in group R developed a significant infection.

The mechanism of this radiation-related effect is likely multifactorial. Radiation is well known to cause masticator fibrosis leading to trismus.[10] Radiation also decreases the vascularity of tissue, making it more sus-

Table 4. Resting Symmetry Analysis

Time Point	Measure	Intact	Paralyzed	*P* Value
Group N				
Pre-TTT	*c*	30.6	22.9	.02
	A	109.2	96.9	.04
Post-TTT	*c*	27.3	28.1	.76
	A	108.8	105.4	.40
Group R				
Pre-TTT	*c*	30.3	20.9	<.01
	A	104.3	93.7	<.01
Post-TTT	*c*	28.9	27.2	.54
	A	102.2	102.8	.89

Abbreviations: *A*, angle formed with the vertical, measured in degrees; *c*, long diagonal or hypotenuse of movement; N, nonirradiated; R, irradiated; TTT, temporalis tendon transfer.

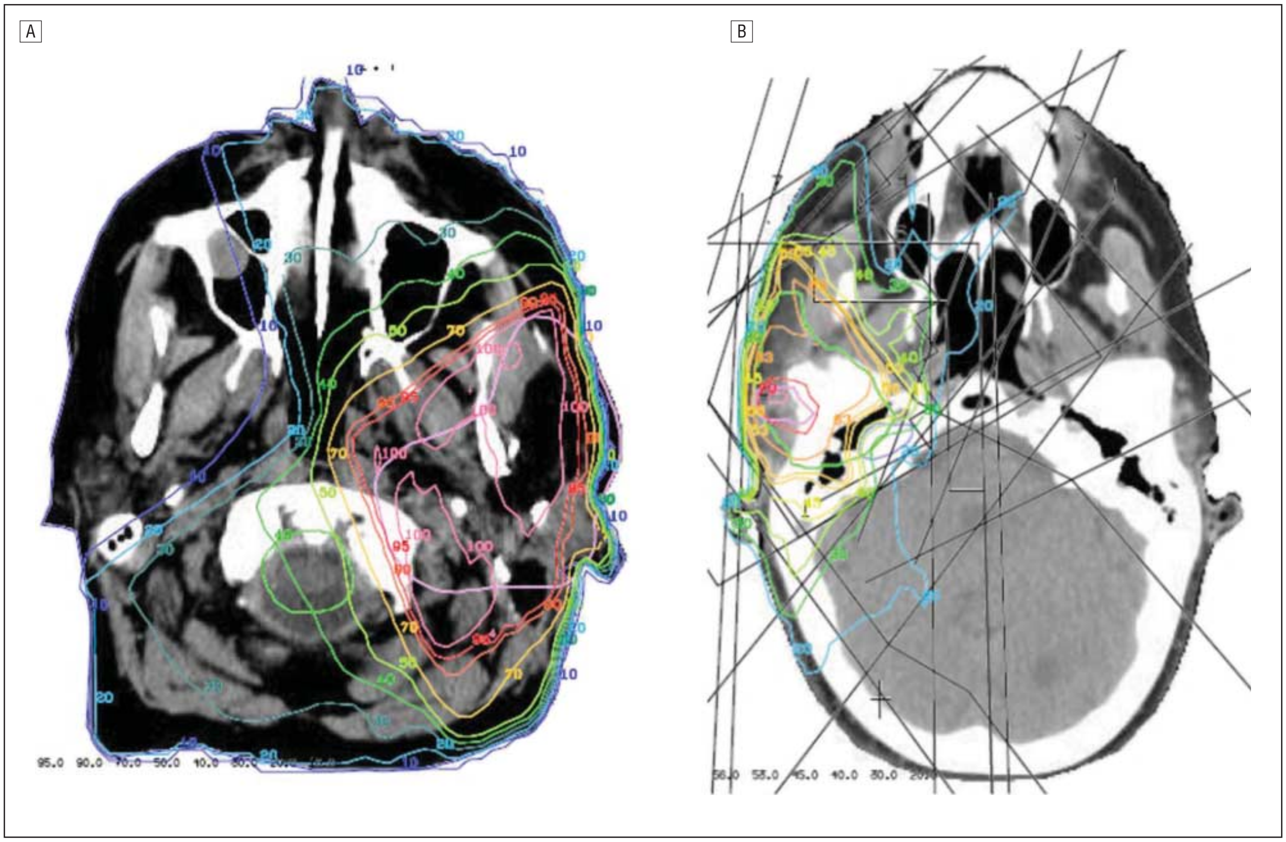

Figure 3. Comparison of conformal and intensity-modulated radiotherapy (IMRT) to the parotid bed. Comparison of treatment planning for postparotidectomy adjuvant radiotherapy using (A) conformal or (B) IMRT. A, Numbers along isodose lines signify a percentage of the maximum. B, IMRT isodose lines refer to the actual dose delivered to that area. Note how the masticator space receives 54 Gy (90% of 60 Gy) with traditional radiotherapy but only 35 to 45 Gy using IMRT.

ceptible to infection and slower to heal. This in turn may lead to a less-efficient glide plane for the manipulated temporalis muscle and tendon to move within. Also, if the fascial extension graft is slow to revascularize in the irradiated bed, it may provide a nidus for infection. None of the irradiated patients in this study received IMRT, which can provide highly conformal XRT dose distributions to spare important normal structures and has been shown to significantly reduce trismus in patients with head and neck cancer.[11] It is possible that the detrimental effects of XRT seen in our study could be mitigated by the use of IMRT (**Figure 3**).

Resting symmetry between the 2 sides of the face was found to be poor pre-TTT as measured by both *c* and *A*, in both groups. However, post-TTT there was good resting symmetry with no statistical difference between the normal and paralyzed sides of the face in either group as measured by *c* and *A*. This suggests that TTT is effective at producing resting symmetry in all patients, even in those who have been irradiated.

The decision to analyze ΔA deserves discussion. Change in *c* is a more direct measure of commissure movement, but we postulate that ΔA is important to include as well. The strong normal facial muscles can pull the smile toward the intact side in patients with unilateral

Figure 4. The importance of angle *A*, formed with the vertical. Patient N4 from the nonirradiated group (group N) after temporalis tendon transfer at rest (A) and smiling (B). The patient is able to produce an acceptable and recognizable smile postoperatively, despite a small Δc=1.6 mm, where *c* is the long diagonal or hypotenuse of movement. This is due to the large ΔA=20.1°.

facial paralysis. When this occurs, the "triangle" of tissue that is measured on the paralyzed side gets smaller overall because there is less lip tissue on that side of the face. As a result, *c* is smaller, potentially leading to a low or negative Δc value. One could argue that the "legs" of the triangle (*a* and *b*) should be measured, but these values would be reduced for the same reason. However, if *A* increases significantly, then the oral commissure will still appear to be moving superiorly, thus fulfilling the goal of communicating a smile to an observer. The post-TTT values for patient N4 reflect this concept well (**Figure 4**).

This study is important because it identifies a patient factor that has an impact on the results of TTT. One weakness of this investigation is that no subjective patient-derived outcome questionnaire data are included. These would be interesting given that irradiated patients did achieve good resting symmetry and may still perceive this as a significant improvement. We to hope to perform a larger multi-institutional study that will include both objective measurements and subjective patient evaluation of benefit. Another potential weakness is the method by which the measurements were performed. We used frontal photographs, which permit evaluation of movement in 2 dimensions (*x* and *y*). However, smiling is a 3-dimensional movement, particularly when generated by the temporalis muscle, which has a significant vector in the anterior-posterior (*z*) plane. Other studies have attempted to solve this problem using three-quarter view photographs. However, such views do not allow automated, computerized measurements to be performed because the irises cannot be used as a standard measure or to set the midline. Rulers can be included in photographs in an attempt to allow postphotography measurement, but these techniques are cumbersome.[12] Furthermore, several recent publications regarding dynamic smile restoration have all used 2-dimensional analysis similar to that reported in this publication.[4,8,9] Three-dimensional cameras have recently been added to several academic facial plastic surgery departments and might allow accurate, automated 3-dimensional measurements of smile in the future.

The results of this study should be taken into consideration when evaluating irradiated patients for facial reanimation. We are particularly concerned about the 2 significant infections that occurred in group R, which may have been related to the placement of a free TFL graft in poorly vascularized environment. One straightforward alternative would be to perform TTT without an extension graft, akin to the technique originally described by Labbé and Huault.[3] In appropriate candidates, single-stage microneurovascular free muscle transfer driven by the masseteric nerve would also be an option. Further evaluation of TTT after IMRT—which may prove to be less detrimental to functional outcomes than conventional XRT—is warranted.

In conclusion, TTT produces less objective commissure excursion in patients who have received radiation to the parotid bed. Both nonirradiated and irradiated patients can achieve good resting symmetry with TTT. Further studies are needed to confirm these findings and to evaluate alternatives to TTT in this patient population.

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