



Some Results of Our Research on Composite Facial Allograft Transplantation in Dogs

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ABSTRACT

Composite facial allograft transplantation is a complicated surgical procedure, requiring evaluation of several questions. How should the facial allograft be preserved? What are the proper surgical skills to reduce surgery duration? Can composite facial allograft transplantation rebuild the motor functions of the facial muscles? In our research, University of Wisconsin (UW) solution was used to preserve canine facial tissue. We manipulated the surgical procedures of complete facial allograft transplantation on cadavers to improve surgery skills. Canine facial allograft models with neuromuscular motor units were performed to evaluate nerve regeneration after allotransplantation. We observed that canine facial allografts could be preserved in UW solution for at least 18 hours. Superficial temporal artery and facial artery bipedicle flaps were safer and saved more time than single pedicle flaps from the external carotid artery. Facial neuromuscular activities were shown in the canine model by the blinking reflex.

MANY PATIENTS suffer from disfigurement of the whole face due to deep burn injuries, extensive tumor ablation, or severe trauma. In some cases, patients often look like “no face” at all. Despite meticulous techniques and artistic creativity, functional and esthetic reconstruction rarely achieves satisfactory results among these poor, difficult cases. Composite facial allotransplantation was thought to be a new hopeful way for these patients. Facial allografts from donors provide a novel, potentially optimal reconstructive option. Composite facial allograft transplantation, especially complete facial allotransplantation is a difficult procedure that requires attention to details to limit its duration. Preservation of the allograft, proper surgical skills, duration, and facial muscle functions are key issues in composite facial allograft transplantation.

SURGICAL SKILLS

The approach to complete facial flap dissection is important in composite facial allotransplantation. The duration of allograft harvest remains a limiting factor to achieve optimal graft survival. Siemionow et al^{1,2} reported the results of mock facial transplantation as well as their surgical strategy to harvest the total facial–scalp flap in cadavers. They chose bilateral external carotid arteries and external jugular and facial veins as pedicles. However, their mean harvest time was 236 minute. Undoubtedly, a surgery duration of 4 hours was too long for acceptable composite facial allotransplan-

tation. We wanted to discover an alternative facial harvesting strategies to shorten the donor-graft procurement and thereby reduce the warm ischemia time.

Twelve fresh human cadavers were randomly divided into two groups: one group with pedicles of superficial temporal artery and on the other side, the facial artery. The cadavers in the other group were dissected with pedicles of bilateral external carotid arteries. We observed that the mean harvesting time (113 ± 6 minutes) using the superficial temporal artery and heterotopic facial artery bipedicle method was significantly shorter than that required by a bilateral external carotid artery (232 ± 6 minutes Alap), because our bipedicle procedure avoided dissection of the complicated anatomy of the carotid and submental triangle; therefore, fewer vessels required ligation.³ Perfusion results showed that unilateral superficial temporal artery with a contralateral facial artery supplied blood for the whole face. Vessel and nerve pedicles also had adequate length for anastomosis. We considered the bipedicle method of complete facial

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allograft harvest to be faster and safer than bilateral external carotid arteries.

CANINE MODELS WITH NEUROMUSCULAR ACTIVITY

Animal models were also indispensable for allotransplantation research. We developed a canine model of composite facial and scalp allograft transplantation to investigate alloimmunity and functional recovery of muscles. We observed that the facial anatomy of the dog is similar to that of humans. The modified canine model, unilateral external ear, orbicularis oculi muscle, and one-third of inferior tarsal plate and palpebral conjunctiva and skin contained an intact nerve-muscle unit with short operative duration (mean 7.5 hours).⁴ Combined application of cyclosporine and corticosteroids produced immunosuppression for canine composite facial/scalp allograft transplantation. Dogs in our test group that underwent composite facial/scalp allotransplantation survived more than 900 days without major complications.

PRESERVATION OF CANINE ALLOGRAFT

Effective preservation of the composite graft is important for allotransplantation. University of Wisconsin (UW) solution has been used to preserve many organ and composite tissue transplants.⁵ We wanted to know if UW solution was suitable for face allograft preservation.

Composite facial grafts including scalps, ears, eyelids, conjunctivas, parotid glands, and mimetic muscles were harvested from dogs. The grafts were preserved at 4°C either in sodium chloride (control groups) or UW solution (test groups). Viability was evaluated after different periods of storage: 0 (fresh/no preservation), 12, 24, 36, or 48 hours by MTT (methyl thiazolyl tetrazolium) assay and histological analysis. The preserved grafts were replanted back to host dogs. Survival area percentages were evaluated at 7 days after replantation.

The MTT assay showed the viability of each tissue in the UW solution group to be significantly better than the control group ($P < .05$; Table 1). Histological results showed good construction and integrity in the UW solution group, with tissue degeneration in the control group. The percentages of survival area of the replanted grafts stored in UW solution were 99.8% at 24, 93.2% at 36, and 85.4% at 48 hours. The most necrotic part of the graft was the neck, followed by the lower eyelid and ear.

The results of our research showed that UW solution was an effective preservation solution for dog composite facial grafts. Facial grafts are rich in muscle and nerve, with a high demand for function recovery. We considered a graft preserved in UW solution for 24 hours to be acceptable for transplantation.

DISCUSSION

Up to now, we have lacked effective measures to restore the appearance and function of patients, who have suffered severe disfigurement of the face from a burn, traffic accident, cancer, and so on. The total facial allograft may be the only way to restore an aesthetic, functional face in the near future. In November 2005, Dubernard and Devauchelle performed a facial allograft on a 38-year-old woman, who was severely disfigured in an attack by a dog.⁶ Many plastic surgeons were thereby encouraged to perform a complete facial allograft. In 2005, Dr W. Hu from Chinese Guangdong Province Hospital performed a penile transplantation for a more cosmetic, functional organ than could be reconstructed using flaps.⁷ Is this sufficient reason for a recipient to obtain immunosuppression for a whole lifetime? In 2004, Dr Jiang from Nanjing China reported a scalp transplantation with two ears and cervical skin on a 72-year-old woman, who was diagnosed with malignant melanoma. Allograft survival was demonstrated; however, the patient died from cancer metastasis 6 months later. Essential questions need to be resolved about a complete facial allograft. The first, confusing question is the indication for a complete facial allograft. A patient who accepts a facial allograft will require immunosuppressive therapy for a lifetime. The key point is how to balance the benefit of an allograft and the side effects of immunosuppression. In the past decades, tissue expanding techniques, microsurgical flap transplant techniques, and prefabrication flap techniques have largely improved the effects of restoring disfigured parts of hair and facial skin, as well as cosmetically reconstructing a nose, ear, or lip. The second question is whether the patient or the surgeon makes the final decision. Patients usually lack professional knowledge to understand the side effects of immunosuppression. Comparison of the benefits and side effects of allograft should be made by surgeons according to defined indications.

In conclusion, many patients suffering "no face" hardly achieve satisfied results by ordinary flap surgeries. Some desperate patients thirsted for better treatments and a

Table 1. Viability Percentages of Tissue in University of Wisconsin (UW) Solution and Sodium Chloride Solution (Ctl)

	0 h		12 h		24 h		36 h		48 h	
	UW	Ctl	UW	Ctl	UW	Ctl	UW	Ctl	UW	Ctl
Skin	100	100	99.02	83.05	98.04	66.36	95.03	55.73	87.02	46.39
Mucosa	100	100	98.06	85.34	94.01	69.46	90.14	52.50	84.97	35.36
Muscle	100	100	94.22	70.94	86.94	56.58	83.58	37.86	77.05	18.46
Vessel	100	100	95.97	78.58	91.97	52.52	88.62	43.71	82.94	34.17
Nerve	100	100	93.02	87.48	87.41	63.49	85.63	38.78	80.92	20.44
Gland	100	100	95.99	75.38	92.05	68.45	89.28	47.63	85.05	40.45

normal appearance. Composite facial allotransplantation is a challenge procedure that brings hope for some difficult cases in plastic and reconstructive surgery. We consider that severe injuries that cover the majority of the facial area with damaged subcutaneous adipose tissues in addition to loss of functions of lip, nose, and eyelids may be surgical indications for complete facial allograft transplantation. However, some key points are still unsolved—for example, the indications for the procedure.

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