Henk J. Klasen

# History of Free Skin Grafting

## Knowledge or Empiricism?

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With a Contribution by Tom Gibson

With 44 Figures

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Dr. Henk J. Klasen
Academisch Ziekenhuis, Oostersingel 59, 9700 RB Groningen, The Netherlands

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# Foreword

Amidst the innumerable articles and books on plastic and reconstructive surgery, a thorough and extensive study of the history of free skin grafting was still missing. This omission has now been rectified by Dr. Klasen.

This book is an expansion of a M.D. thesis, written at the State University of Groningen, The Netherlands, and was guided by Professor A. J. C. Huffstadt, plastic surgeon, and Professor D. de Moulin, medical historian. Professor T. Gibson kindly revised the manuscript and wrote the epilogue. But, as Goethe put it: "nur ein Teil der Kunst kann gelehrt werden, der Künstler macht das Ganze" ("only a part of the art can be taught, the artist makes the totality").

The author, Henk Klasen, is a remarkable man. As a general surgeon, he devotes all his interest and skills to traumatology and problems of physiology and pathophysiology in surgery. With such talents it is natural that he also works parttime as one of the coordinators of a modern burn unit.

Among his hobbies are love of antiques and old books.

This historical inclination has induced him to write the present book, in which he vividly describes the development of free skin grafting in its relevant theoretical and practical aspects. His elaborate study has resulted in an excellent reference book which at the same time provides enjoyable reading, once again demonstrating the value of history in understanding the present.

A. J. C. Huffstadt, M.D.
D. de Moulin, M.D.

# Preface

A period of more than 100 years separates the first free skin graft from skin grafts as they are performed today. In this time, several aspects of skin grafting have evolved step by step.

This thesis presents an account of this evolution and discusses such aspects as indications, grafting methods, preparations, technical procedures, and the evaluation of results.

The data for this survey were obtained from the literature, comprising British, American, German, French, Scandinavian, Swiss, Austrian, Russian, and Dutch journals and books. Publications which could not be traced were not included.

The evolution of various aspects of skin grafting is discussed in chronological order. First, a survey is presented of attempts at skin grafting prior to Reverdin's invention. The chapter which discusses Reverdin's method of skin grafting illustrates the great influence of skin grafting on the treatment of wounds and ulcers.

A separate chapter is devoted to the importance of skin grafting in palpebral surgery. In this branch of surgery, skin grafting had an entirely separate development.

The next chapter outlines the importance of Thiersch and his influence on his contemporaries.

The evolution of various aspects of skin grafting in the 20th century is discussed in two chapters. One covers the period from about 1900 to 1930, while the other deals with the period from about 1930 to 1950. The periods are rather arbitrarily chosen. The year 1900 is convenient because at that time in general the interest in skin grafting had decreased, but during and after World War I the interest increased again. In the period of 1930–1950, World War II was a dominant factor. During the war and thereafter up to 1950, many new developments were published. In a few cases in which the year 1950 did not signify the end of some particular development, publications of a later date are also included.

The term "skin grafting" will be frequently used. Skin grafting will be defined as "transfer of skin from one site of the body to another, with complete interruption of the blood supply".

Occasionally, the pleonasm "free skin graft" will be used in order to avoid confusion with (pedicled) flap. Flaps are sometimes incorrectly referred to as "grafts" (Rogers 1959). In flaps, however, the blood supply is not interrupted completely.

We define "split-skin grafts" as grafts which consist of epidermis and part of the corium, whereas "full-thickness grafts" comprise the epidermis and the entire corium together.

For the reader's convenience, efforts have been made to ensure optimal uniformity of terminology. In some instances, terms are used which differ from those used by the authors in their original publications.

The term "autografting" is used when the donor is the same individual as the recipient.

Since this is a historical survey, it is regarded as justifiable to use the "old-fashioned" terms "homografting" and "heterografting" rather than the currently more widely employed terms "allografting" and "xenografting". Homografting (allografting) is the transfer of a graft from one individual to another individual of the same species. Heterografting (xenografting) is the transfer of a graft from one individual to another of a different species.

H. J. KLASEN

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# Chapter 1
# Experiences With and Views on Skin Grafting Prior to Reverdin's Invention (1869)

Nearly all historical reviews on skin grafting refer to India, where the technique is believed to have been used for centuries; by way of illustration, Dutrochet's article in the French *Gazette de Santé* (Dutrochet 1817) is then mentioned. The widely quoted article was actually a letter to the editor in which Dutrochet, a physician, recounted the experiences of his brother-in-law. The latter, a high-ranking army officer in India, had described the following events to Dutrochet:

> An officer serving under the brother-in-law had punished one of his subordinates by having the man's nose cut off. The man then sought out Indians who were known for their ability to reconstruct a nose by surgery, and requested them to perform this operation on him.

Next, Dutrochet described the operation which the Indians were believed to have performed on this man:

> Because the defect was already showing cicatrization, the wound edges were freshened. One of the man's buttocks, which was to be the donor site, was beaten with an old shoe until a substantial swelling was achieved. From this swollen area, a triangular piece of skin, with subcutaneous fat, was then cut and placed on the defect. It was fixed in position with adhesive plaster. The graft healed, and the man continued to serve in the brother-in-law's command.

While this case history is not entirely impossible, the last line in the second case history cannot be true:

> A man had been caught looting, and one of his ears was cut off by way of punishment. The man wanted a new ear, but his own ear had been thrown away and could not be found. The ear of a pariah was therefore bought, cut off and used to replace the ear of the punished man. The grafting was successful . . .

At the end of his letter Dutrochet mentioned that he himself had made several attempts at grafting on animals, but that none had been successful. He assumed that this was due to the fact that the grafts had not been prepared (by beating).

This article has some incredible passages, which cast doubt on its veracity. The reliability of the article was indeed soon considered debatable. Zeis (1863) qualified the experiences recounted in the article as fables (the fact that he could react to the article 46 years after its publication illustrates that the medical literature of that time did not become outdated as quickly as in our time). He pointed out that this had been a single publication, and that nothing had since been heard about skin grafting in India. Marchand (1901) called Dutrochet's story a fantasy which mixed the operation of the pedicled flap with legend. Nevertheless the article attracted much attention and was translated in several foreign medical journals. Sometimes

only a part of the article was published (Dittmer 1817; Villeneuve 1817). Gibson (1963) discovered that the English translation did not come from the *Gazette de Santé* of 1817, but from a version published by Blandin (1836). Unfortunately, Blandin had mentioned only the first of the two case histories of the original article and ignored the case history of the ear transplantation.

Brock (1952) described how Sir Astley Cooper (1768–1841) in London had successfully performed a human skin graft in 1817. Cooper had already shown his particular interest in transplantations by several experiments. The description of this operation was recorded in a rough notebook Cooper kept for notes on museum specimens, surgical procedures and other accounts. The abstract was written by an unknown person.

Hartfield was a young man admitted into Guys Hospital (Cornelius Ward) on April 9th 1817, with a diseased thumb which Mr. Cooper, now Sir Astley, amputated between the phalanges on the 18th of July. He then cut off a healthy piece of integument from the amputated part and applied it to the face of the stump where he secured it by means of adhesive slips.

*1st week to July 25th*, union seems to have taken place.

*2nd week to August 1st*, Mr. Cooper proved the vascularity of the newly attached portion by pricking it very slightly with a point of a lancet, which produced fluid blood as readily as from any other part of the joint. Sensibility has not returned.

*3rd week from operation.* In the course of this week sensation has returned in the end of the stump.

*September 23rd*, the stump appeared quite well. [1]

A year later, in 1818 and 1819, three newly graduated Dutch physicians (Tilanus, Broers and De Fremery) made a hiking tour to various European university cities. In the course of this tour they visited the university of Marburg in Germany, and made the acquaintance of Bünger, professor of anatomy and surgery. Bünger received them cordially and gave them an account of several case histories, including one which involved a successful skin graft. One of the visitors (Tilanus) recorded Bünger's observations about this operation in his diary (Deelman 1925).

It was not until three years later that a report on this skin graft was published in the *Journal der Chirurgie und Augen-Heilkunde* (Bünger 1822) (Fig. 1), at the explicit invitation of one of the editors of the journal (Gräfe 1821).

Bünger described in detail why he had not used a pedicled flap, as some surgeons were already doing at that time. The anatomical situation had more or less forced him to resort to a free skin graft. Bünger and an assistant inspected the wound on the third day after grafting, in the presence of several of the patient's relatives. In a moving account of what he and his assistant felt when they saw that the graft was taking, Bünger wrote:

Wir Aertze sahen uns nur starr an, und trauten erst unsern Augen nicht, indem wir den Tags zuvor kreideweissen Lappen, der wenigstens anderthalb Stunden dem Lebenseinflusse vom übrigen Körper entzogen gewesen war, jetzt in der Form einer Nase an dem beträchtlichsten Teile seiner Oberfläche rein scharlachroth glänzend und aufgedunsen erblickten . . . [2]

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1 This case history has also been mentioned by Zimmerman and Veith (1961) and by Balch and Marzoni (1977).

2 We doctors looked at each other in silence and did not believe our eyes when we saw that a graft which the day before had been chalk-white and had been deprived of the vital forces from the remainder of the body for at least 90 minutes, now had become a nose which for the most part had a pure scarlet colour and looked glossy and swollen . . .

**Fig. 1.** Christian Heinrich Bünger (1782 – 1842), anatomist and surgeon in Marburg, Germany, who performed the first, well documented full thickness skin grafting in 1817

Bünger's attempt had been inspired by Dutrochet's report in the *Gazette de Santé*. Although he had had his doubts about the method, he thought an attempt would do little harm to the patient.

Transplantation was performed to replace the nose of a woman of 33 years old. Except that the woman had been very pretty before her nose was destroyed by a destructive process and that she had already visited many doctors, Bünger gave no information about the patient or her illness.

He did not use a buttock as donor site, as mentioned in Dutrochet's story, because this would inconvenience the patient and impede sitting and lying. Another argument was that wound toilet and the changing of dressings would be difficult. He therefore selected the venterolateral aspect of the upper thigh as donor site. In accordance with the Indian example, this area was beaten with a leather belt until the skin looked red and swollen. A piece of skin measuring $10 \times 7.5$ cm was then excised, with half of the thickness of the layer of subcutaneous fat attached. The graft was then trimmed to the desired shape and used to "replace" the malformed nose. The graft was fixed to the freshened wound surface by means of sutures. The dressing, consisting of a layer of cotton wool, was fixed in position with adhesive plaster.

The graft still looked dead-white on the second postoperative day, but one day later it had assumed a reddish colour, with the exception of the lower edge which was blue. As Bünger had feared, this edge became necrotic and it had to be excised on the ninth postoperative day.

Five weeks after the operation, all skin defects had healed. The layer of dry, dead epidermis had been shed much earlier. After healing, the reconstructed nose

was growing the same kind of hairs as the donor site. One year after the operation the grafted skin still differed in colour from the rest of the face.

Not long after Bünger's description Dieffenbach (1824 a) a celebrated German surgeon, and one of the founders of plastic surgery in Germany, published his report on a skin graft that he had performed largely as an experiment.

This was part of the treatment of a 40-year-old woman suffering from sensory disorders and reduced muscular strength in the left half of the body. The physicians in charge believed that application of exogenous stimuli to the anaesthetic half of the body would have a beneficial effect on the disease process. Dieffenbach assumed that this could best be achieved by a kind of "exchange" skin graft. Prior to grafting, the skin on the flexor side of the forearm was stimulated by rubbing with alcohol, Dieffenbach apparently being influenced in this regard by Dutrochet's publication. A piece of skin the size of a thaler (diameter: 35 mm) was cut from this area 24 h later. The thickness of the graft was not specified. A skin fragment of the same dimensions was excised from the extensor side of the forearm, without previously stimulating the area. The portions of skin were exchanged and placed in the fresh wounds. They were held in position by means of adhesive plaster. The wounds were inspected after six days. The graft placed on the flexor side of the forearm "floated in pus"; the epidermis was still attached to it. The "prepared" graft placed on the extensor side of the forearm looked quite different. The epidermis had become detached, half of the graft had become putrified, but the remainder was attached to the underlying structures and was surrounded by granulation tissue. Unfortunately, this fragment was inadvertently pulled loose from the underlying structures when the dressing was changed, whereupon both graft and wound began to bleed. According to Dieffenbach, the bleeding proved that the circulation had meanwhile been restored. Both skin defects subsequently healed within a few days. It was in fact even claimed that there was no scar.

Apart from this clinical experiment, Dieffenbach (1824 b, 1830) performed many experiments in an effort to establish the feasibility of skin grafting in birds, rabbits, cats and dogs. Not only was skin grafted from one bird to another but also from mammals to birds. All these attempts failed because the grafts became desiccated. Dieffenbach suspected that this was due to the high body temperature of the birds. In another experiment, a piglet's skin was grafted on a pigeon. The graft dried out, but the hairs in the grafted skin were reported as having resumed growing after 8 days. The test animal was sacrificed 10 days after the operation. The graft was found to be attached to the wound floor, but was not vascularized. Other experiments in rabbits and dogs likewise failed.

In one rabbit, however, the tip of the nose was successfully reattached. In one series of experiments, a piece of skin with a diameter of 1 cm was excised from rabbit ears, and reapplied to the area after haemostasis. Although the experiment was repeated as often as 50 times, only three rabbits showed reattachment of the skin. In these experiments, too, the vitality of the grafts was "stimulated" by rubbing and beating.

Attempts to graft skin at other sites, e.g. the back or the head in rabbits, also failed. In all cases the top layer of the graft, including the hair roots, was shed, where-upon epithelialization of the intact layer of the graft occurred.

Other attempts made by Dieffenbach to graft human skin were all failures. He made these attempts in patients in whom tumours had been extirpated. The skin which had covered the tumours was used to cover the defects. In none of these patients did the autografts take. Yet Dieffenbach was convinced that well-vascularized skin should be suitable for grafting. He expected that scrotal skin had the best characteristics for this purpose – an assumption based on the fact that, after excision, scrotal skin changed its size and shape. This skin, therefore, "had to be" still vital.

Dieffenbach's experiments were resumed in the same thorough way by Hanff of Berlin in 1870 (Hanff 1870). He was unaware of the successful skin graft performed by Reverdin in 1869. Hanff performed his experiments not to prove that tissues from certain parts of the body could grow at other sites (he considered this a proven fact), but to study the healing process. Grafting experiments were done on homoiothermic and poikilothermic animal species. The grafts consisted of skin, subcutaneous fat and fascia or muscle tissue. Hanff found that skin could be transplanted without difficulty from one frog to another. He did report, however, that bleeding occurred beneath the grafts 9–14 days after the operation, although the grafts had initially shown adequate attachment.

By that time the recipient frogs gave an impression of lassitude. Microscopic examination after sacrificing the animals revealed that the grafts had become attached to a thickened, highly cellularized fascia layer.

Hanff considered the frog the most suitable test animal for skin grafting because grafts could be easily obtained, and the subcutaneous fascia of the frog provided a good underlying structure for grafting. Attempts to graft frog skin onto wounds covered with granulation tissue failed.

Hanff concluded from his frog experiments that the graft had to be larger than the defect to be covered; that after 2–3 days the epidermis, with the Malpighian layer, detached itself from the rest of the graft, and that grafts were nourished via the floor of the wound.

Hanff's experiments on poikilothermic species consisted of autografting, homografting and heterografting in dogs and rats. The grafts consisted of skin together with a layer of subcutis. After haemostasis, the grafts were applied without any tension and sutured. Hanff observed that the grafts initially attached themselves, but became detached after 9–12 days. In his evaluation of results he made no distinction between autografts, homografts and heterografts. None of these grafts healed completely; partial healing was observed in three cases (he did not specify whether these were autografts).

Hanff maintained that graft healing was a stepwise process. The superficial graft parts furthest from the nourishing wound bed ran the gravest risk of becoming necrotic. The grafting result depended on the speed of revascularization and the progressive degeneration of the graft. A few hours after operation the graft was already attached to the wound bed. This phenomenon deeply impressed Hanff, and was emphatically mentioned several times. After 24 hours, union between graft and wound floor should have been established – as manifested by swelling of the grafts. Although he considered this a favourable omen, it did not imply that healing would in fact occur. Further healing was effected in that the graft was incorporated in the vascular system, but this took some more time. During this period the graft was

prevented from degenerating by an "inflammatory plastic" (entzündlich-plastisch) process.

This process was nothing but the inflammatory reaction which in his opinion was always associated with grafting. White blood corpuscles were already present in the wound 4–6 hours after infliction.

According to Hanff, these white blood corpuscles were converted to connective tissue cells after 48 hours. The "plastic" reaction then ceased, and granulation tissue was formed, which then enclosed the graft. Once the granulation tissue had interposed itself between grafted tissue and wound floor, Hanff believed, the relation between floor and graft was established. Direct adhesion of graft to wound floor, he maintained, did not prevent the inflammatory reaction but did prevent the suppuration which occurred in other wounds. The white corpuscles, Hanff assumed, probably played a role in suppuration. He expected that white corpuscles might also turn into tissue cells. The zone in which suppuration occurred formed the boundary between the vital and the dead graft tissue. Hanff believed that, via the blood vessels, the white corpuscles entered the exudate between wound floor and transplant, and then infiltrated the graft; subsequently, the blood vessels supplying the graft were formed. He therefore assumed an unmistakable relation between the presence of leucocytes in the graft and the restoration of the circulation. Moreover, he was convinced that granulation tissue and the "plastic, infiltrative" reaction in the graft were produced by the same process. Graft healing was therefore to be expected up to the layer in which these reactions occurred, but the more superficial layers would degenerate. Once the degenerated tissue was shed, epidermis (he probably meant epithelium) was formed from the wound edges; and this covered the intact part of the graft.

Hanff concluded that grafts degenerated unless early vascularization developed. Since skin consisted largely of connective tissue, it was more resistant than most other tissues and therefore the most suitable for grafting. Hanff considered the loss of "epidermis" in skin grafting to be of secondary importance, and he maintained that the significance of the serous transudation should not be underrated. In his opinion, attempts to stimulate the vitality of the graft by provoking an inflammatory reaction (by alcohol rubbing or beating, according to the ancient Indian rules) were of little value.

The work of Hanff did not attract much attention because of the earlier invention of Reverdin. However it should be appreciated that Hanff was the first to describe extensive microscopic studies in this field, which became possible through the development of histological colouring techniques, good microtomes and improvements to the microscope.

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