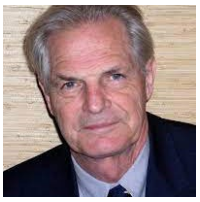

DENYS MONTANDON, MD – SWITZERLAND

PART 1. SKIN EXPANSION AND ELONGATION

SURGICAL USE OF PROGRESSIVE TISSUE EXPANSION AND ELONGATION SINCE ANTIQUITY

Figure 1: Elephantiasis (filariosis) of scrotum, penis, and lower limbs. Patient operated on by Dr. Brigitte Pittet in Benin.

As we all know, progressive tissue expansion is a natural phenomenon of the body during growth, obesity, and pregnancy. It is also observed in several pathologic conditions, the most impressive being lymphedema, Recklinghausen disease, and Marfan's disease. Lymphatic filariasis, commonly known as elephantiasis, may lead to almost infinite skin expansion, particularly if it affects the scrotum ***(Figure 1)***.

Artificial tissue expansion has also been a custom in several ethnic groups, as a tradition or to signify the appurtenance of a special caste. The insertion of a metallic ring of increased diameter into the lower lip was particularly common among Manguias women of Zambezia and other African ethnic groups and is still practiced today among Brazilian Indians, as is the case of Chief Raoni ***(Figure 2)***, who recently visited the United Nations in Geneva to protect his population and the Amazonian Forest. Earlobe elongation with heavy rings was also a common practice in the Vietnamese Djaraïs and on Easter Island, where the population was once divided between two groups: the *long-ears* and the *short-ears*, the first being the dominant group. In some cases, the distended earlobes may have an enormous length so as to reach the clavicles. Pseudo-elongation of the neck, with multiple heavy rings added since childhood, is practiced among the Padaung or Kayan women in Myanmar. These heavy coils will eventually depress the clavicles and the first ribs at an angle of up to 45 degrees. Only a minimal increase in intervertebral discs has been noted on X-rays.

Figure 2: Brazilian Indian Chief Raoni Metuktire with expanded lower lip.

For the ancient Greeks, particularly the athletes who had to perform nude during the games, a long prepuce was a sign of respectability, and they took care to prevent unwanted exposure of the glans penis[1]. For the Greeks, the prepuce was composed of two distinct structures: the *posthe* and the *akroposthion*, distally. The consistent artistic portrayal in paintings of the adult penis with a generously proportioned *akroposthion* may well represent an anatomical ideal. It was considered by some to have a similar aesthetic and protective value, as the eyelid for the eye. In ancient texts, it is mentioned that many athletes applied a device called the *kynodesme* (literally a "dog leash") ***(Figure 3)***, a thin leather thong wound around the *akroposthion* that pulled

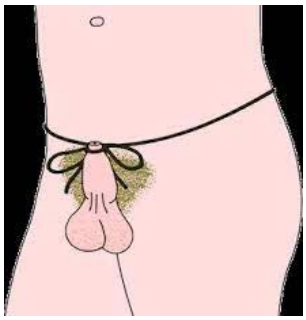

Figure 3: Ancient Greek athlete's kynodesme.

the prepuce and the penis upward and was tied in a bow, or around the waist. It is also known that the condition called lipodermic penis (lipodermos = lack of skin), or short foreskin, allowing the glans to be visible, was somehow humiliating and males affected by lipodermos, were seeking some type of correction.

THE GAIN OF SKIN IN SURGICAL PRACTICE

The majority of reconstructive plastic surgery operations require the adjunction of well-vascularized skin and soft tissues. Various types of flap transfers have been used for centuries, but the possibility to gain skin by expansion is relatively new. Today, skin expansion with an inflatable balloon has become an indispensable tool for many kinds of plastic surgery procedures. In 1957 C.G. Neumann was the first to have the idea of using a subcutaneously placed rubber balloon to obtain expanded skin for the reconstruction of a partially avulsed ear[2]. This method was long forgotten until the 1976 ASPRS meeting, when the American-Yugoslavian plastic surgeon, **Chedomir Radovan** (1932–1984), presented his method of skin flap expansion with a silicon inflatable prosthesis[3]. Not very well received at the time, Radovan persisted with his idea, which caught the eye of Bill Grabb who proposed that this method would be one of the most important plastic surgery developments of our age. Radovan developed skin expansion mainly for breast reconstruction in collaboration with the Heyer-Schulte Company, producing the inflating prosthesis. According to Roger Khoury and his collaborators, breast enlargement could also be obtained using an external tissue expansion system.

In the head and neck region, after the first case report of Neumann in 1957, one had to wait for the publications of Radovan, before skin expansion became a frequent method for various procedures. All types and sizes of inflatable prosthesis are designed for indications such as scalp reconstruction, or as a preliminary maneuver for a forehead flap used in nasal reconstruction, allowing an easy closure of the forehead. Lip retractions after electric burns or other pathologies have been treated since the early 20th century with mechanical distractors to enlarge the commissures, however, it does not create new tissues. On the other hand, using a small inflatable prosthesis, we were able to expand a remaining lip stump with its vermillion border, to reconstruct an important lip defect in a case of noma[4]. Several other uses of expanding, and therefore enhancing, the proliferation of skin and soft tissue have been described for better closure after the harvesting of flaps in the limbs and the thorax.

SKIN ELONGATION

Considering only surgical skin expansion with an inflatable balloon might lead us to forget that other means of progressive enhancement of the skin surface and proliferation have been described in the past, and still have their indications today. Since the most ancient times, circumcision has been widely performed in most Egyptian, Arab, Phoenician, and Jewish boys, but during Greek and Roman Antiquity, it was considered as a mutilation and a severe aesthetic deformity, often leading to racial discrimination. As for today, a few circumcised men sought reconstruction of their foreskin for various reasons, mainly for better integration in certain societies, to avoid recognition of their religion or origin, or for physical and psychological reasons. One of the first mentions of actual uncircumcision can be traced back to the Old Testament (I Maccabees 1:14–15), "So they built a gymnasium in Jerusalem, according to Gentile custom, and removed the marks of circumcision, and abandoned the holy covenant. They joined with the Gentiles and sold themselves". This passage illustrates the dominant Hellenized culture of that age[5].

Figure 4: The Pondus Judaeus.

Several methods of foreskin reconstruction performed at that time have been reported, using a progressive stretch of the remaining foreskin. For this, surgeons used the so-called *Pondus Judaeus* ***(Figure 4)*** made of leather, analog to the Greek *kynodesme*, and attached to the inner thigh. Other methods mentioned weight produced by the *krikos* for the Greeks or the *fibula* for the Romans, piercing rings made of bronze or copper, that could be fixed to the rudimentary preputial skin to pull it downward[5] ***(Figure 5)***. We are indebted to the Roman encyclopaedist **Aulus Cornelius Celsus** (c. 25 BC – c. 50 AD)

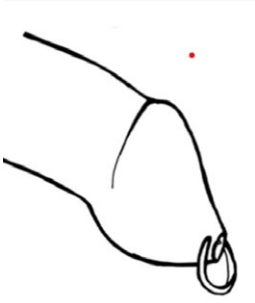

Figure 5: The krikos or fibula.

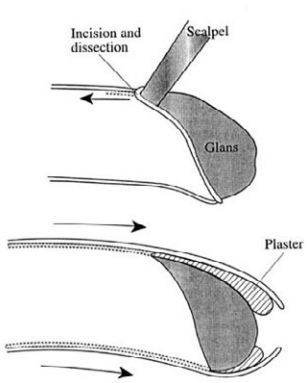

Figure 6: Celsus uncircumcision operation according to Rubin (1980).

for writing in detail, operations that were probably described and practiced by Greek surgeons in Alexandria[6]. In cases where conservative circumcision had been performed, leaving some of the inner layers of the prepuce intact, the skin was incised in a circular fashion, around the base of the penis, and mobilized distally, stretching over the glans. The neo-prepuce was ligated, leaving a small opening for urinating. In the second method, a subcoronary incision was made, and a full-thickness dissection was performed of the shaft. The elastic penile skin was pulled over the glans and ligated at the distally, and a non-adherent lead-oxide plaster was applied to prevent adhesion to the glans ***(Figure 6)***. Similar methods using progressive skin expansion for uncircumcision operations have been reported later during the Middle Ages by Oribasus (325–403 AD) and Paul of Aegina (625–690), and in the 19th century by the well-known German surgeon **Johann Friedrich Dieffenbach** (1792–1847). In his works, he compiled a chapter on what he called *posthioplasty* operation, also paying tribute to Celsus. Most of the modern methods of foreskin reconstruction are founded on these ancient operations, making use of skin stretching and expansion.

SKIN EXTENSION BY GRADUAL EXCISIONS

In 1915, Hippolyte Morestin (1989–1919), the famous French surgeon of World War I, wrote an illustrated article entitled, "La réduction graduelle des déformités tégumentaires" [7] (The gradual reduction of tegument's deformities), where he shows in several examples how he was able to remove extended facial naevi with iterative simple operations, allowing the skin to expand progressively, "I have described earlier the method of spontaneous autoplasty by progressive stretching of the integuments ..., my present method is based on the same principle, it utilizes the nearly indefinite possibility of extension of the skin; it leads to spontaneous autoplasty, but by a quite different procedure" ***(Figure 7)***.

CONCLUSION

For generations, mankind acknowledged the possibilities of tissue growth when submitted to progressive physical expansion, traction, or distraction. Except for the uncircumcision operations described by Celsus, and a few scattered reports, one had to wait until the end of the 20th century before surgeons could make real practical use of this natural phenomenon. Today, we know that putting skin under tension initially forces interstitial fluid out of the tissues and causes micro-fragmentation of the elastic fibers and changes in the alignment of collagen, allowing greater expansion of the skin, termed 'creep'. Recruitment of adjacent mobile soft tissue also contributes to this initial phase of tissue expansion. A prolonged skin stretch induces an increase of the cellular mitotic rate, together with an increase of collagen content and ground substance dimension, which gives rise to true tissular growth, analogous to other regenerating mechanisms[8].

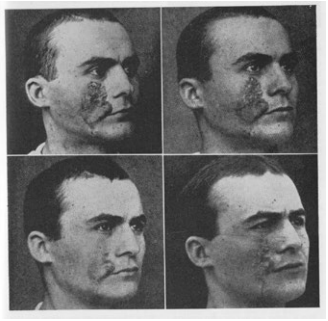

Figure 7: Skin expansion by gradual excisions (Morestin 1915).

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