REVIEW OF FORESKIN ANATOMY, FUNCTION, DEVELOPMENT, AND CARE

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John Taylor, the Canadian pathologist whose groundbreaking research on the anatomy of the foreskin provides a foundation for appreciating its functionality, has said,

> In the equation, the value of the actual foreskin is often put at zero. Put a value on it. It is a structure in its own right (Milne, 2001).

A review of the essential facts about the anatomy, function, and natural history of the foreskin is presented here, in the interest of demystifying, normalizing, and ascribing value to a unique body part that few Americans – including health professionals – are familiar with.

The Anatomy of the Intact Penis

Overview of the Penile Skin System

The phalluses of virtually all mammals, male and female, have some kind of sheath or covering (Cold & Taylor, 1999). In the human male, this covering is called the foreskin, also known as the prepuce (adj. preputial).

The foreskin is not a discretely demarcated structure, but is an integral part of the skin system of the penis. The penile skin begins from a point of attachment at the pubic mound, and continues forward along the shaft and usually some distance beyond the tip of the glans. It then doubles back under itself to attach in the sulcus behind the corona of the glans (see Figure 1). Thus the foreskin is not – as it is commonly described – a simple "flap of skin," but a double-layered fold of tissue. Neither is the foreskin "just a piece of skin," but consists of uniquely differentiated and specialized tissue. The foreskin's outer

layer is continuous with and the same type of tissue as the regular skin of the penile shaft. However, its inner layer is mucous membrane, as is the surface of the glans of the intact penis. Mucous membrane is the thin moist tissue that lines the inner cavities of the body (Tortora & Derrickson, 2006). Thus, like the glans clitoris, the glans penis in the non-erect state is naturally designed to be an internal structure. Nor is the foreskin "just a *little* piece of skin." Due to the double-layered nature of the foreskin, when unfolded, the actual amount of tissue subject to removal by circumcision is on average about 50% of the skin with which the penis is naturally endowed (J. R. Taylor, Lockwood, & A. J. Taylor, 1996). What may be a quarter-sized area in the newborn may equate to fourteen square inches of tissue in the adult penis (Werker, Terng, & Kon, 1998).

Except for its two points of attachment at the pubis and the coronal sulcus, the entire length of the tubular penile skin – including the two layers of its forward fold, the foreskin – is not tethered to the underlying structures of the penis. Thus it is free to glide extensively over the penile shaft, as well as to furl and unfurl over the head of the penis with manual retraction, erection, or the motions of sex. The skin mobility of the intact penis is unique in the body, and plays a significant role in sexual function, as will be discussed later (Scott, 1999).

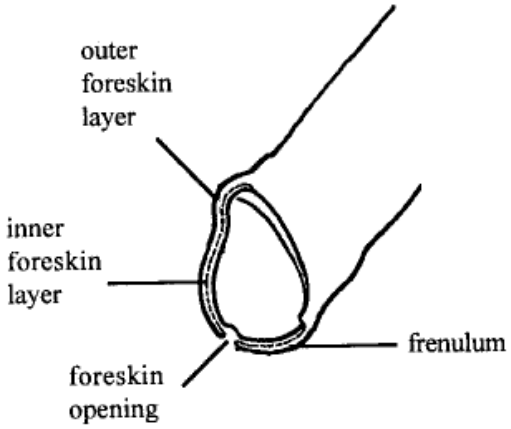

Figure 1: Cross-section of the Structure of the Intact Penis.
From *The Joy of Uncircumcising!* 2nd Edition, by James Bigelow.
Morris Publishing, Kearney, NE, 1998. Used with permission.

The skin system of the penis and scrotum contains a thin layer of muscle called the dartos fascia, or peripenic muscle (Jefferson, 1916). This is the muscle that, in the presence of cold, contracts to draw

the male genitalia closer to the body. Due to the foreskin's double-layered structure, when in its normal forward position, the foreskin contains two layers of muscle. The tone of this double muscle layer allows the foreskin to fit snugly over the glans throughout life (Lakshmanan & Prakash, 1980). At the opening of the foreskin, the muscle fibers are arranged in a circular pattern that gives the outlet sphincter-like properties (Jefferson, 1916; Lakshmanan & Prakash, 1980). Thus the foreskin opening can relax to allow urine to flow out, then contract again after voiding to prevent the introduction of contaminants. The state of contraction or relaxation of the peripenic muscle can affect the apparent tightness or openness of the preputial opening found during a clinical examination (Jefferson, 1916).

Because the penile skin sheath does not attach to underlying structures except at its ends, it has its own vascular system separate from the deeper structures of the penis (Werker et al., 1998). This superficial penile blood supply travels along the shaft skin and through the prepuce. While some of the superficial blood vessels end at the border of the glans, other branches enter the glans and provide part of the blood supply to the ventral glans and the urinary outlet (Hinman, 1991; McGrath, 2001). When these vessels are truncated with circumcision, the normal circulation to these areas can be disrupted. The naturally reddish or purplish coloration (the "vascular blush") of the inner foreskin and glans in the intact penis is due to the capillary beds rising close to the thin mucous membrane surface.

Protective Functions of the Foreskin

As previously mentioned, the glans is designed to be an internal structure, normally exposed only during sexual arousal. In the flaccid state, the glans is covered by the prepuce, which protects it, the urinary opening, and the inner foreskin itself in a number of ways.

In the baby and child, the foreskin is normally fused to the head of the penis (Das, 1993) and the preputial outlet is naturally tight (Lakshmanan & Prakash, 1980). (The development of the intact penis is discussed later in this section.) Also in the baby and child, there is typically some overhang of the preputial fold past the tip of the glans (Jefferson, 1916). This overhang helps to keep the preputial space and the urinary opening at a greater distance from the exterior environment. These features prevent entry

of contaminants underneath the foreskin during the diaper years, working in concert with the foreskin's sphincteric action, which closes the preputial space off from the exterior environment in between voids (Fleiss, Hodges, & Van Howe, 1998). Voiding itself helps keep the foreskin free of contaminants. Multiple times a day, the preputial outlet is flushed outward with the passage of urine, which is sterile as it exits from the bladder.

The foreskin's coverage also protects the glans and urinary opening from friction, drying, and injury. Without the coverage of the foreskin, the glans of the circumcised penis becomes keratinized, or thickened, due to constant exposure to air and friction (Cold & Taylor, 1999). Although the foreskin's primary function is often said to be to protect the sensitivity of the glans, the glans is in fact inherently not very sensitive to light touch (Halata & Munger, 1986; Sorrells et al., 2007). However, by preventing thickening of the surface of the glans, the foreskin optimizes what light-touch sensitivity the glans does have (Sorrells et al., 2007). The coverage of the foreskin also protects the glans against damage from a variety of chemical and mechanical irritants, such as ammonia in diapers and chafing with exercise. The vascularity of the foreskin keeps the glans warm and protected from cold in extreme conditions.

The urinary opening, or meatus, is particularly delicate mucosal tissue. While the foreskin protects the meatus of the intact penis from irritation, in the circumcised penis, the urinary opening commonly becomes inflamed during the diaper years, due to exposure to urine, feces, and friction, a condition called meatitis (Patel, 1966; Van Howe, 2007). Meatitis may progress to ulceration and eventual scarring, a condition called meatal stenosis in which the urinary opening is constricted with scar tissue. Meatal stenosis is found in 7-10% of circumcised males, and is almost never seen in intact males (Angel, 2006; Van Howe, 2006b). Besides local irritation, it is hypothesized that loss of blood supply to the urinary outlet, from truncation of the frenular artery with circumcision, may also contribute to the incidence of meatal stenosis (Angel, 2006).

In addition to its mechanically protective functions, the foreskin provides immunological protection as well. While more research is needed, human and animal studies exist that indicate the presence of immunoactive cells in the foreskin and immunoprotective substances in the preputial space. For example, lysozyme, an immunologically active enzyme on mucous membrane surfaces and in

secretions such as tears, saliva, and mother's milk, has been found in the moisture under the human foreskin (Parkash, Jeyakumar, Subramanyan, & Chaudhuri, 1973). Also, maternal antibodies in breastmilk are excreted in the infant's urine and prevent *E. Coli* from adhering to the urinary tract and inner foreskin (Fleiss et al., 1998). Plasma cells in the prepuces of bulls have been found to increase in number in response to bacterial infection, and to secrete immunoglobulins into the preputial space in response to bacterial infection (Fleiss et al., 1998). Langerhans cells are immunoactive cells found in the skin and certain mucous membrane surfaces, including the foreskin and vagina. Recent research on human tissue samples has shown that these cells produce a protein called Langerin that helps to scavenge viruses from the environment and transport them elsewhere in the cell for destruction (de Witte et al., 2007). While some authors have claimed that Langerhans cells in the foreskin are a portal for HIV infection (Szabo & Short, 2000), and have used this claim to argue for circumcision as a way to prevent HIV, de Witte et al. (2007) conclude, in contrast:

> Langerin is a natural barrier to HIV-1 infection, and strategies to combat infection must enhance, preserve or, at the very least, not interfere with Langerin expression and function (p. 367).

Finally, like the vagina, the foreskin has its own internal ecology of bacterial flora (Fleiss et al., 1998). It is known that excessive use of soap under the prepuce can disturb the floral balance, and contribute to inflammation of the foreskin and glans (balanoposthitis) (Birley, Luzzi, & Bell, 1993; Fleiss et al., 1998).

Anatomical Factors Relating to the Foreskin's Sexual Functions

Most of the scientific understanding of the sexual functionality of the foreskin has developed since the late 1990s. Following is a review of some of the anatomical features of the foreskin that are indicative of its sexual function.

Mucocutaneous junctions are specialized areas of tissue that constitute the primary erogenous zones of the body (Winkelmann, 1959). A mucocutaneous junction (L. cutis = skin) is a region of tissue where the regular skin transitions into mucous membrane. The rim of the preputial fold is one such region, where the external penile skin transitions into the mucous membrane surface of the inner foreskin. Besides the foreskin, mucocutaneous junctions are found elsewhere in the body, such as the lips, anus, nipples, and vulva. The chief characteristic of these areas is that they typically display an increased quantity and specialization of nerves endings, allowing for heightened touch sensitivity and erogenous sensation (Winkelmann, 1959).

As with other mucous membrane surfaces in the body, the inner mucosal layer of the foreskin tends toward more acute sensation than the outer cutaneous layer (Sorrells et al., 2007). This is because the mucous membrane epithelium is thinner than the keratinized external skin, and because the networks of nerves rise closer to the surface in mucous membrane surfaces than they do in regular skin (Winkelmann, 1959). The mucosa of the prepuce is divided into two zones, the ridged mucosa and the smooth mucosa (J. R. Taylor et al., 1996). A mucosal band of 10-12 small ridges, totaling about 1 cm. wide, loops just within the mucocutaneous junction of the preputial opening. It merges bilaterally downward into the frenulum, a web of tissue that tethers the inner foreskin to the underside of the glans. The smooth mucosa comprises the remainder of the inner prepuce, attaching to the shaft behind the corona. While the inner foreskin layer is normally shielded against the glans in the flaccid state, with erection, in the adult, the penile shaft elongates out of the preputial fold, causing the inner mucosal layer of the foreskin to evert along the shaft of the penis (see Figure 2).

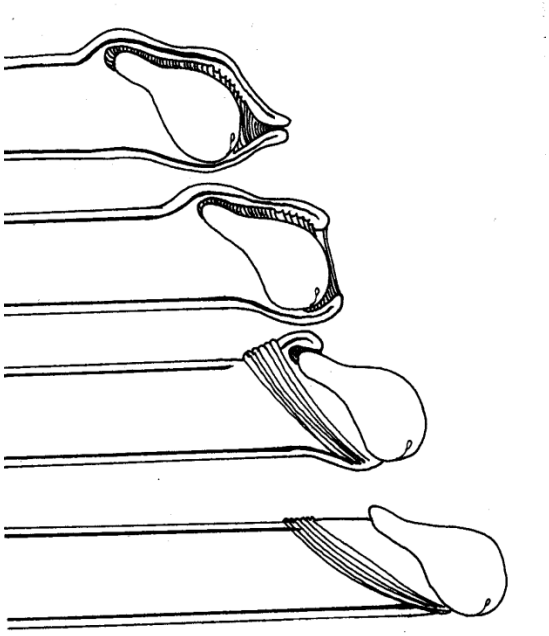

Figure 2: Eversion of the Foreskin, Showing the Ridged Band.
Adapted from Figure 4, p. 16, in "The Anatomy and Physiology of the Prepuce" by Steve Scott. *Male and Female Circumcision: Medical, Legal, and Ethical Considerations in Pediatric Practice.* Edited by G.C. Denniston, F.M. Hodges, and M.F. Milos. Kluwer Academic/Plenum Publishers, NY. 1999. With kind permission from Springer Science and Business Media.

An anatomical study by J. R. Taylor et al. (1996) of the prepuces of 22 adult males obtained on autopsy, found that the inner foreskin contained high concentrations of Meissner's corpuscles, the type of nerve ending that is responsible for fine-touch sensitivity, for example, the extreme tactile sensitivity of the fingertips and the lips. The Meissner's corpuscles were found to be particularly densely concentrated in the ridged band of the inner foreskin of the samples studied, where they were found to cluster on the crests of the mucosal ridges, but were not found in the valleys between the ridges. This distribution, putting the concentrations of Meissner's corpuscles in contact with adjacent structures, strongly suggests the sensory function of the ridged mucosal band. In contrast to the foreskin, the glans has few Meissner's corpuscles – approximately 10 times fewer than the foreskin – instead containing predominantly free nerve endings (Halata & Munger, 1986) whose function is the detection of more primitive and poorly localized sensory input, such as pain, heat, cold, and extreme deep pressure

A recent study by Sorrells et al. (2007) on the fine-touch sensitivity of the adult penis, conducted on 68 intact men and 91 circumcised men, confirms Taylor et al.'s anatomical findings (see abbreviated set of results in Figure 3). Using Semmes-Weinstein monofilament testing, the authors mapped fine-touch

pressure thresholds at 19 penile locations, 8 present only in the intact male, and 2 present only in the circumcised male (the dorsal and ventral scar lines). In both circumcised and intact men, the glans was found to be the least fine-touch sensitive location on the penis, with the glans of the circumcised penis significantly less sensitive than the glans of the intact penis ($P = 0.040$). The corona of the glans was found to be the most sensitive part of the glans, although still of a relatively low sensitivity. Of all the penile locations tested, the preputial orifice rim (the mucocutaneous junction) was the most sensitive to fine touch, approximately twelve times more sensitive than the glans. Five locations present only on the intact penis (i.e. those removed with circumcision) were found to be more sensitive to fine touch than the most sensitive location on the circumcised penis, the ventral circumcision scar ($P < 0.0001$). The authors concluded that "circumcision removes the most sensitive parts of the penis" (Sorrells et al., 2007).

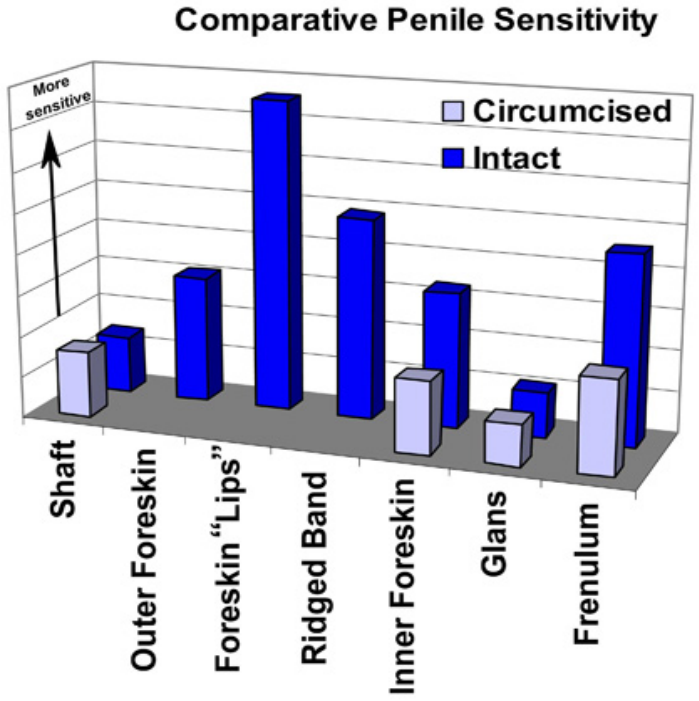

Figure 3: Fine-touch Sensitivity of the Circumcised Versus the Intact Penis.
Adapted by Dan Bollinger from data found in Sorrells et al., 2007. Used with permission.

Several other groups of investigators that have performed sensory studies comparing the circumcised and the intact penis have concluded that there is no significant difference between the sensitivity of the two. However, two of these studies did not examine the sensitivity of the foreskin,

testing only single points on the glans and shaft of the penis (Masters & Johnson, 1966; Payne, Thaler, Kukkonen, Carrier, & Binik, 2007). A third study tested a single point on the dorsal midline of the outer foreskin (the least sensitive area on the foreskin, according to Sorrells et al.'s data), in addition to testing the glans and shaft (Bleustein, Fogarty, Eckholdt, Arezzo, & Melman, 2005). Sorrells et al.'s study is the only one to date to map the comparative sensitivity of the circumcised and intact penis over multiple points, including multiple points on the foreskin.

Sexual Functions of the Foreskin

The evidence on the sexual functionality of the foreskin comes not only from anatomical and touch-testing studies such as those discussed above, but also from surveys of adult men before and after circumcision (Collins, Upshaw, Rutchik, Ortenberg, & Albertsen, 2002; Coursey et al., 2001; Fink, Carson, & DeVellis, 2002; Kigozi et al., 2008; Kim & Pang, 2007; Masood et al., 2005; Senkul et al., 2004; Shen, Chen, Zhu, Wan, & Chen, 2004; Solinis & Yiannaki, 2007); a survey on the sexual experiences of women with circumcised versus intact partners (O'Hara & O'Hara, 1999); studies of effects on lubrication and intromission (Bensley & Boyle, 2001; Bensley & Boyle, 2003; O'Hara & O'Hara, 1999; Taves, 2002); and anecdotal reports from men who have non-surgically restored their foreskins, thereby regaining coverage of the glans and mobility of the penile skin (National Organization of Restoring Men (NORM), 1999-2006; Bigelow, 1998).

Results from studies of men's sexual satisfaction and performance before and after circumcision have produced mixed results. While some have found no differences (Collins et al., 2002; Kigozi et al., 2008), others have indicated problems with erection (Fink et al., 2002; Shen et al., 2004), ejaculation (Senkul et al., 2004; Shen et al., 2004; Solinis & Yiannaki, 2007), penile sensation (Fink et al., 2002), and masturbatory ease and pleasure (Kim & Pang, 2007). Overall, a worsening in sex life has been reported in about one third of cases (Dalton, 2008). Before and after studies are, however, subject to multiple methodological problems that make them unreliable or difficult to interpret (Silverberg, 2008; Sorrells et

al., 2007). A full analysis of these studies is beyond the scope of this article, and they will not be considered in the following discussion on the foreskin's sexual functions.

Based on what is known of the foreskin's sensory capacities and mechanical properties alone, the foreskin can be understood to have a variety of sexual functions that affect the pleasure and comfort of both partners. Figure 4 shows the mechanics of intercourse with an intact penis, to illustrate the following discussion. The sexual functions of the foreskin include at least the following:

1) The penis elongates by at least 50% with erection (Wessells, Lue, & McAninch, 1996). The slack in the penile skin afforded by the preputial fold provides *comfortable coverage* of the shaft as it expands with erection, while still allowing for skin mobility. In contrast, the skin of the circumcised penis is generally relatively taut and immobile with erection, with the expansion of the organ restricted by a significantly reduced skin complement. Some circumcised men report experiencing such tightness with erection as to produce pain or even tearing of the skin (Hammond, 1999).

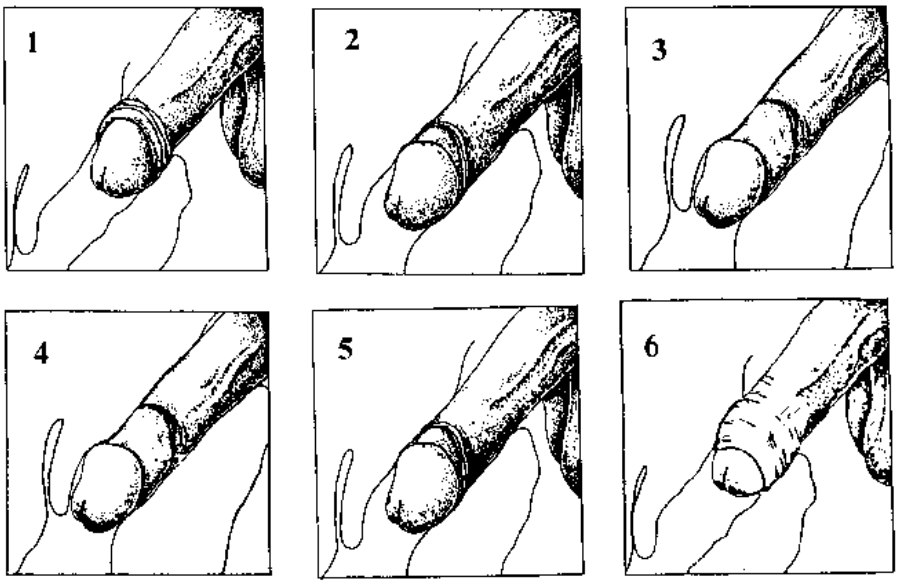

Figure 4: The Intact Penis and the Dynamics of Intercourse.
Adapted from *Foreskin* by Bud Berkeley, private publication, 1983. Used with permission.

2) The double-layered fold of the foreskin acts as a *rolling bearing* during intercourse. Once the penis is inserted, friction from the vaginal walls holds the skin of the penis relatively stable, allowing the shaft of the penis to glide in and out of its own skin sheath with the motions of intercourse, instead of

rubbing back and forth directly against the vaginal wall. This *gliding, non-abrasive movement* makes intercourse more comfortable for both partners (O'Hara & O'Hara, 1999; Scott, 1999). The mobility of the intact penile skin also plays a facilitating role in foreplay, masturbation, and insertion of the penis (Kim & Pang, 2007; Taves, 2002). One physician described the latter function in this way:

> Penetration in the circumcised man has been compared to thrusting the foot into a sock held open at the top, while, on the other hand, in the intact counterpart it has been likened to slipping the foot into a sock that has been previously rolled up (Morgan, 1965).

3) Given the action of the shaft within the penile skin sheath with intercourse, at the end of the outstroke the glans is engulfed in a bunched up cuff of foreskin. This acts as a dam to retain natural *lubrication* within the vagina. In contrast, without the foreskin cuff, the exposed coronal rim of the glans of the circumcised penis tends to squeegee lubrication out of the vagina with each outstroke. Also, since the taut penile skin of the circumcised penis follows the shaft out of the vagina with each outstroke, the moist shaft skin is exposed to air drying repeatedly (Bensley & Boyle, 2003; O'Hara & O'Hara, 1999). The comfort and ease afforded by the foreskin's gliding action and lubricating function may be especially significant for post-menopausal women.

4) Besides the simple presence of the *fine-touch sensing capacities* of the foreskin, the intact penis has built-in *self-stimulating capabilities*. During intercourse, the concentrations of Meissner's corpuscles near the outlet of the foreskin are stimulated in multiple ways (Scott, 1999). The densely innervated ridged mucosa is intermittently deployed along the shaft of the penis in contact with the vaginal wall, while at the same time the ridged band is stimulated by rhythmic stretching from the tethering of the frenulum. In addition to this, the foreskin and ridged band repeatedly roll back and forth over the corona of the glans with the motions of intercourse. This contact provides more of the fine-touch stimulation for which the ridged band is designed and, at the same time, the corona – the most fine-touch sensitive part of the glans – receives stimulation from the moving foreskin.

5) Because of the erogenous sensations generated in the interaction between the glans and the foreskin, the penile shaft does not have to move very far back and forth to achieve satisfying sexual stimulation. This produces a *different dynamic to intercourse* with typically shorter strokes, compared to the elongated strokes and more vigorous thrusting reportedly more often employed by circumcised men

(O'Hara & O'Hara, 1999). In a qualitative survey of women who had had sexual experience with both intact and circumcised men, the great majority reported that intercourse was gentler and more comfortable with the intact partners, and that they were more often able to achieve orgasm with intercourse alone (possibly due to the closer contact allowed with the woman's pubic area) (O'Hara & O'Hara, 1999).

These are some of the most obvious mechanical and sensory functions of the foreskin. As an integral part of the natural penis, the foreskin may have other significant sexual functions that are not yet appreciated or understood. Some authors have indeed expressed the view that the prepuce is necessary for physiologically normal sexual functioning (Cold & Taylor, 1999; Falliers, 1970; Fleiss & Hodges, 1995). Much more research is needed in this area.

Development and Care of the Intact Penis

The penis of the infant and child differs from the adult penis in some significant ways. When it first develops in utero, the foreskin is fused to the head of the penis, from which it later releases as the child grows to adulthood. This is similar to the way the eyes of a kitten are fused shut at birth to protect the developing organ, and then open naturally on their own with time. An understanding of the natural development of the intact penis is necessary for assuring safe, correct care of the boy's genitals by both parents and professionals.

Development of the Intact Penis

In the fetus, the external genitalia of both males and females develop from the same rudimentary structures (Das, 1993). Under the influence of hormones, the genital tubercle becomes the glans clitoris in the female and the glans penis in the male. The urogenital folds remain open in the female to produce the vaginal orifice, and fuse in the male along the underside of the penis to place the urinary opening, or meatus, at the tip of the glans. Both males and females have a prepuce to cover the glans, the foreskin in

the male and the clitoral hood in the female. In the male, the prepuce begins to form at about 8 weeks gestation, originating as a ring of tissue at the coronal sulcus that gradually grows forward over the glans as a double-layered fold (see Figure 5). By 16 weeks gestation, the prepuce is fully formed and generally completely enfolds the glans, although there is a normally variable range of length. It is normal for the foreskin of the infant and child to have considerable overhang, appearing as a tubular extension beyond the glans. The length of the overhanging tissue is taken up to some degree with the growth of the penile shaft during puberty.

As the prepuce develops in utero, the advancing inner foreskin layer and the glans share a common cell layer that firmly attaches the inner foreskin to the glans. This cell layer is known as the balanopreputial membrane (Gk. balanos = acorn [the shape of the glans]). Fusion of the inner prepuce and the glans is the normal state at birth and during the early years of life. In addition, the outlet of the foreskin is naturally non-elastic in childhood (Lakshmanan & Prakash, 1980). The tight, fused foreskin protects the infant's glans and urinary opening during the diaper years, and is the normal state during childhood.

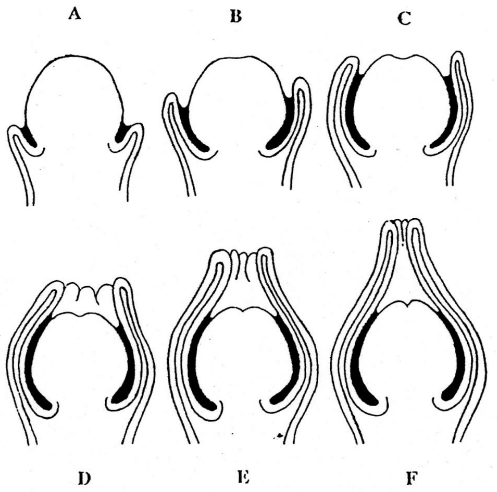

Figure 5: The Embryological Development of the Foreskin.
Adapted from Figure 2, p. 11, in "The Anatomy and Physiology of the Prepuce" by Steve Scott. *Male and Female Circumcision: Medical, Legal, and Ethical Considerations in Pediatric Practice.* Edited by G.C. Denniston, F.M. Hodges, and M.F. Milos. Kluwer Academic/Plenum Publishers, NY. 1999. With kind permission from Springer Science and Business Media.

As the intact boy's penis develops, two processes occur naturally by which the foreskin eventually becomes retractile. One process is the separation of the foreskin from the glans. Whorls of cells form in the common cell layer between the foreskin and the glans, and degenerate from the inside out, creating spaces in the balanopreputial membrane. Over time, these spaces eventually coalesce to form a completely free space beneath the foreskin (Deibert, 1933). The other process is the loosening of the foreskin's non-elastic opening. As the child grows toward adulthood, the tight opening of the prepuce becomes invested with a greater proportion of elastic fibers, making the opening more stretchy (Kayaba et al., 1996; Lakshmanan & Prakash, 1980). These two processes progress simultaneously over a very variable period of time, although one may advance before the other.

The assertion that most boys should be retractable by age 3 or age 5 is frequently found in the medical literature. This information comes from a study published 60 years ago by British pediatrician Gairdner (1949). At that time, it was believed, incorrectly, that the foreskin should be retractable within days after birth (Deibert, 1933), and boys who were not retractable were said to be suffering from "congenital phimosis" (Gk. phimosis = muzzling
[an inability to retract the foreskin]).[1] Because an unretractable foreskin was also thought to be a source of a multitude of problems, young English boys were commonly subjected to dilating procedures and forced retraction by physicians, and parents were advised to forcibly retract the foreskin (Darby, 2005). Gairdner examined 300 intact English boys, age birth to 5 years, and found that only 50% were fully retractable by age 1, but that by age 3, 90% were fully retractable and 92% by age 5. Gairdner's study was significant because it showed that it was normal for babies not to be retractable, and made the case for eliminating unnecessary interventions and circumcisions in young children based on the previous misunderstandings. Because this was the first study of its kind, these results entered into the medical literature as the definitive information on the normal age of retractability. However, because the study had been done on a population likely to have been subjected to premature forced retraction of the foreskin, the ages found for

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[1] It is crucial to distinguish physiological versus pathological non-retractability. The former is the developmentally normal state in which the separation and loosening of the foreskin has not yet been completed. In contrast, pathological non-retractability refers to histological changes in the foreskin tissue caused by some kind of damage or disease process. The use of the term "phimosis" is most appropriately used in the latter case (Hodges, 1999; McGregor, Pike, & Leonard, 2007).

retractability may well have been abnormally early. Indeed, Gairdner's data have never been confirmed by any subsequent study, yet despite criticism (Wright, 1994), his incorrect age expectations are still commonly cited by physicians and in the medical literature today (AAP, 1999).

In 1968, a follow up to Gairdner's work was published by Danish school health physician Øster (1968), who followed nearly 2000 Danish schoolboys ages 6 through 17 over a period of up to eight years. Unlike England, Denmark has never practiced infant circumcision. It is possible that the cultural perception of the foreskin as normal rather than as a potential source of pathology may have produced a more casual, hands-off approach to care of the intact penis in this population. In contrast to Gairdner, Øster found a much later age distribution relating to retractability, for example, it was not until age 10 that 50% of intact boys were fully retractable, with 97% found to be fully retractable by age 17. Øster noted that the percentage of boys who were not fully retractable decreased progressively with age without any outside intervention, and that no problems with hygiene were found despite the extended developmental period. Øster's results have since been confirmed by numerous studies in Japan, Scandinavia, and other countries that have never practiced circumcision (Agarwal, Mohta, & Anand, 2005; Imamura, 1997; Ishikawa & Kawakita, 2004; Kayaba et al., 1996; Ko et al., 2007; Morales Concepcion et al., 2002; Thorvaldsen & Meyhoff, 2005) (see Figure 6). Kayaba (1996), in particular, documented the twin dimensions of increasing separation of the foreskin from the glans, along with decreasing tightness of the preputial opening. As with Øster's results, these studies have typically found the average age at full retractability to be about age 10, with the vast majority of intact boys naturally fully retractable by the end of adolescence. One study suggests that the developmental processes described may naturally continue into early adulthood (Thorvaldsen & Meyhoff, 2005).

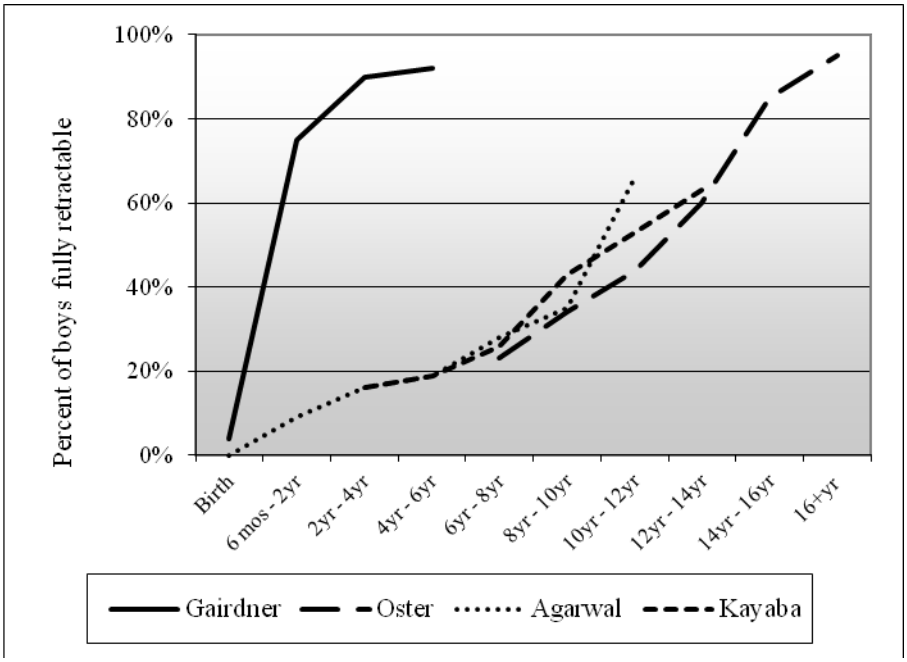

Figure 6: Age at Full Retractability.
Adapted by Gillian Longley from data found in the original papers.

Besides the age at retractability, other normal variations may occur in the development of the intact penis. For example, as the foreskin separates, shed cells may accumulate under the foreskin, as a whitish or slightly colored (depending on skin color), pasty or dry, generally odorless material is called smegma (Gk. soap, emollient). Smegma was once believed to be carcinogenic, causing medical authorities to place great importance on its removal by washing, but this claim is not supported by the scientific evidence (Van Howe, 2006). Smegma is a benign substance, and is released from the foreskin opening on its own over time as the foreskin continues to separate (McGregor et al., 2007). Ballooning of the foreskin with voiding is another variation that occurs in some boys, when separation has occurred to some degree underneath the foreskin but the outlet is still tight. Ballooning is non-pathological and requires no treatment (Babu, Harrison, & Hutton, 2004; McGregor et al., 2007; Rickwood, 2002). It is a sign that separation is proceeding but not yet complete, and disappears as the foreskin opening becomes looser. Variability in the development of the intact penis is the rule, and the process is unique for every boy.

Care of the Intact Penis

There are no controlled studies of the optimal approach to care of the intact penis, of the type that assigns groups of boys to different care protocols and then compares outcomes. One survey of 47 intact males, age 2 weeks to 52 years, correlated retraction for washing to a decreased incidence of foreskin problems (Krueger & Osborn, 1986). The problems observed for included "adhesions," "phimosis," and the presence of smegma – all potentially normal developmental findings depending on the age of the patient. Failing to correctly adjust for the age of the subjects, the authors concluded that retraction with washing *prevents* phimosis and adhesions, whereas it is more likely that normal non-separation of the foreskin was the *reason* that patients did not retract for cleaning. Aside from this one flawed study, most of the information available on care of the child's foreskin consists of opinion pieces. Such opinions would ideally be based on extensive clinical experience with the intact penis and accurate, thorough knowledge of the anatomy and development of the intact penis. Unfortunately, the professional advice found on the care of the intact penis often appears to be based on mistaken notions about the age of retractability, or reflects preconceptions of the foreskin as inherently problematic. American health professionals, coming from a generation unfamiliar with the intact penis, may only be taught that parents must retract the child's foreskin regularly to clean under it, but know little of the process or true timing of the events leading to retractability (Doctors Opposing Circumcision (DOC), 2008b; Osborn et al., 1981), nor have any understanding of the harm that premature, forcible retraction can cause (Bollinger, 2007; Geisheker & Travis, 2008)

The most widely agreed upon principal in care of the intact penis is that the foreskin should never be forcibly retracted. Virtually all references on care of the intact penis caution against forcible retraction. Premature forcible retraction can lead to pain, bleeding, infection, paraphimosis (a condition in which retraction of a tight foreskin causes it to become stuck behind the corona of the glans), as well as scarring and adhesions that can cause problems with retraction later in life (acquired pathological phimosis) (Bollinger, 2007). Some sources advise early "gentle, partial retraction" by the parent, several mentioning starting at a specific age of 1 or 2 (Rao, 2004; Schmitt, 2007). However, this recommendation shows a

lack of understanding of the normal age range and natural progression leading to retractability. On the other hand, other sources specifically recommend letting the child be the first to retract himself (National Organization of Circumcision Information Resource Centers (NOCIRC), 2007; Swafford, 1967; Wright, 1994). The rationale for this is that only the boy will know how much force is too much, thus avoiding the risks of forcible retraction. Others sources state to simply "leave it alone" (Bratt, 2005; Iannelli, 2004; Watson, 1987).

Care instructions beyond the above considerations are simple (AAP, 2000; NOCIRC, 2007). Care of the intact penis is easy to do and easy to teach. If the foreskin is not retractable, the parents or the boy should wash off the outside only. As the boy gets older, teaching about care of the penis can be incorporated into other hygiene teaching. Once retractable, the boy can start to wash underneath the foreskin occasionally in the shower or clean tub water. The "3 Rs" are a helpful mnemonic for foreskin care: retract the foreskin (boy retracts himself), rinse underneath, and replace the foreskin back forward. By puberty, if retractable, it is recommended that rinsing underneath be performed more regularly, i.e. daily. Soap is not necessary and can be irritating (Birley et al., 1993).

Foreskin Problems: Prevention and Conservative Treatment

Like any other part of the body, the foreskin can occasionally have problems. However, it has been said that the worst problem that an intact male is ever likely to have is that someone else *thinks* they have a problem (NOCIRC, 2007). Most issues can be prevented by the commonsense care measures discussed above and respect for the body's natural developmental process. Any foreskin problems that do occur are almost always treatable with conservative approaches, and there are few absolute indications for circumcision. The Canadian Pediatric Society (2004) estimates that 1% of intact boys may need to be circumcised later in life, however, data from countries that have never practiced circumcision indicates that the true need for later circumcision may be much lower (Wallerstein, 1980). A discussion of foreskin problems and their conservative treatment is beyond the scope of this article. The reader is referred to a number of useful articles and resources available on this topic, with the caveat that not all sources are

equally knowledgeable on the evidence on normal foreskin development (Camille, Kuo, & Wiener, 2000; "Conservative non-surgical treatment," 2009; DOC, 2008a; Fleiss, 2000; McGregor et al., 2007; Ritter & Denniston, 2002; Simpson & Barraclough, 1998).

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