

**TITLE: Nonoperative Facial Rejuvenation**  
**SOURCE: Grand Rounds Presentation, UTMB, Dept. of Otolaryngology**  
**DATE: February 25, 2010**  
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## **Introduction**

Since the dawn of time humans have been obsessed with their outward appearance. From shoes to tattoos and breast lifts to brow lifts we will do anything to look our best. When it comes to our facial appearance, nothing can be harder on our image than mother nature herself. Sagging skin, scars, and sun damage all date the years we have put on our skin and over the years we have been quite thrifty in finding ways to attempt to reverse these afflictions.

In 3000 BCE the Egyptians were using bath houses, facial tattoos, and makeup to hide their facial distortions, and by 1500 BCE they had developed an early form of dermabrasion with sandpaper to help reduce the scars they had accumulated on their faces (1, 2). Jewish Law in 100 BCE went so far as to say that a husband is required to provide 10 dinars per month for the cosmetic appearance of their wives. In 200 CE the Romans became involved with the process as Ovid, in his book *The Art of Love*, wrote of a homemade facial mask that was meant to rejuvenate the skin. In 900 CE the Arabic physicians also came up with an early form of dermabrasion composed of marble, seashells, and other coarse objects that were used to exfoliate and smooth the face (3).

In the recent past dermabrasion as we know it was first introduced using the wheel and rasp in 1905 by Kromayer (4). Over the past century, the techniques for rejuvenation of the face have rapidly progressed leading to the development of chemical peels in the 1940's and 1950's, laser resurfacing in the 1990's, and most recently a boom in the different preparations of dermal fillers over the last decade.

In this paper we will review anatomy of the skin and the process of skin damage, and then discuss the different options available for nonoperative facial rejuvenation and their associated complications.

## **The Skin**

The skin is composed of 3 layers including the epidermis, the dermis, and the hypodermis. The epidermis is the initial barrier of the body to the outside world. It is a 5 layer continuum from stratum basale where cells are regenerated every 12-14 days to the stratum corneum where keratinocytes are sloughed off as dead skin cells (1). Along this continuum are three intervening layers; stratum spinosum, stratum granulosum, and stratum lucidum (deep to superficial) which show increasing degrees of maturation and keratin production as you move more superficially. Additionally found in the basal layer are melanocytes important for skin pigmentation.

The dermis is the next layer, deep to the epidermis. It is composed of 2 layers, the papillary and reticular dermis. The papillary dermis is present more superficially at the dermal epidermal junction. It houses fibroblasts that produce a meshwork of type III collagen, and anchors the epidermis down to the dermis. The reticular dermis consists of type I collagen, elastin, and glycosaminoglycans. Glycosaminoglycans interestingly can hold up to 1000 times their weight in water thus adding to the turgor of the skin (5). In addition to connective tissue, the reticular dermis is also the host of nerve fibers, blood vessels, hair swells, and sweat/sebaceous glands which are the latter are important for re-epithelialization.

The deepest layer is the hypodermis which is composed of loose connective tissue, fat and elastin important for anchoring the skin down to the bone and muscle. Predominant cells include fibroblasts, adipocytes, and macrophages

## **Damage to the skin**

As the skin ages and the damaging effects of the sun and environmental toxins like tobacco smoke act on the skin several changes begin to occur. In the epidermis the stratum corneum thickens and the stratum spinosum thins. In the dermal layer the high ratio of type I to type III collagen decreases and tissue collagenases and gelatinases increase thus facilitating the degradation of collagen and elastin in the dermal layer (6). Ultimately this leads to decreased elasticity and skin turgor resulting in increased sagging of the skin and deepening of wrinkles (7).

## **Initial Examination**

When a patient first comes to the office inquiring about options for facial rejuvenation a couple of things must first be elicited. Patient expectations are of vital importance. If a patient has unrealistic goals or objective it is important to make the patient aware of what you can and cannot do for them. Treatment before setting these ground rules can result in unhappy patients and lawsuits. Parallel to this idea of realistic goals is the need to look for patient with psychiatric instability or those who “doctor shop.” These patients are at increased risk of having unrealistic expectations and are more likely to have poor outcomes based on those expectations. Finally, patients who smoke are at 12 times increased risk of scarring from facial plastic procedures. Therefore it is important to require smoking cessation before treatment and/or properly document informed consent of their increased risk of scarring and treat only if the patient accepts these risks. These are all important components of the patient’s history.

On physical exam you first want to look for skin conditions that may increase the risk of complication or undesirable outcome. Hyper- and hypo pigmentation increase the risk of pigmentary irregularities after treatment. Collagen vascular disease increased the risk of inappropriate collagen formation and scarring. Active infection also increases the risk of infection.

In order to evaluate the most appropriate form of treatment you must also decide if rhytids are dynamic or adynamic. Dynamic rhytids will resolve with manipulation of the skin in antagonistic directions to the muscle causing rhytids. These rhytids are more commonly treated with botulinum toxin in order to prevent over activity of the muscle in question. Adynamic rhytids that are due to photoaging do not correct with antagonistic motion and therefore are not amenable to botulinum toxin therapy. This is an important distinction to make before beginning treatment.

Finally you want to assess skin thickness and the depth of injury that has occurred. The Glogau scale has been used to define depth of injury and will be described below in Table 1 (8).

| Category | Damage                                 | Skin Findings                           | Treatment                              |
|----------|--|---|--|
| I        | Stratum Granulosum or Papillary Dermis | Fine wrinkles                           | Superficial skin peels or dermabrasion |
| II       | Upper Reticular Dermis                 | Wrinkles with facial gestures           | Medium depth peel or laser resurfacing |
| III      | Upper Reticular Dermis                 | Wrinkles at rest                        | Medium depth peel or laser resurfacing |
| IV       | Mid Reticular Dermis                   | Wrinkles at rest and skin discoloration | Deep peel or laser resurfacing         |

Table 1. Table comparing the different depths of skin damage using the Glogau scale and their associated treatment options.

### **Dermabrasion**

As discussed earlier, dermabrasion has been around in 1 form or another since at least 1500 BCE. The purpose of dermabrasion is to injure the superficial layer of cells to promote re-epithelialization of the epidermis and collagen deposition in the dermis. Indications for dermabrasion are traumatic and acne scarring, adynamic rhytids, and rhinophyma. It is contraindicated in cases where patient have had hypertrophic scars or keloids in the past as this increases the risk of unsatisfactory results. The key to dermabrasion is to only damage down to the papillary dermis. If you injure deep to the papillary dermis and into the reticular dermis, you may damage pilosebaceous units and impair re-epithelialization.

It can be performed in the office with local anesthesia, but may require IV sedation. Either a brush or diamond fraise is used to perform the procedure. Mobile subunits like the malar fat pads can be frozen prior to the procedure in order to have a rigid surface for debridement. Feathering is a technique used to blend the edges of the debrided area to make the skin appear more uniform.

Patients having dermabrasion performed may have some punctuate bleeding from the skin on the day of the procedure which can be controlled with occlusive dressings. Erythematous skin and re-epithelialization will persist for 7 to 10 days with complete healing around 2 to 3 weeks.

Microdermabrasion is a technique that has really become popular at local beauty stores and boutiques. Microdermabrasion utilizes an aluminum oxide microcrystal to remove the superficial layers of the dermis. The advantage being that it can be performed at relatively short intervals, it is painless requiring no anesthesia, and it has much less erythema as a result of superficial damage. The disadvantages, however are that it only affects the upper layer of the epidermis and cannot treat deeper rhytids that originate in the dermis

In 2001, Freedman et al. (9) looked at the just 10 patients treated with 6 sessions of microdermabrasion. They evaluated patients both with facial analysis and tissue biopsy. They found that not only were fine rhytids improved with the procedure but also that dermal collagen had actually increased post-therapy. This latter finding was paradoxical because the microdermabrasion does not penetrate to do injury in the dermis. In 2010 a review article by Karimipour (10) concluded that microdermabrasion is useful for fine or superficial rhytids, it is not useful for deeper rhytids or dyschromias, and although there are no RCTs looking at its use in acne, patients should be individually evaluated and treated on a case by case basis depending on the acne scarring severity.

## **Laser Resurfacing**

Lasers work by damaging tissues via thermal heat. In order for tissues to receive the thermal damage the laser has to be absorbed by a chromophore within the cell that the laser is specific to. Several different chromophores are used including water, oxyhemoglobin and even melanin. The more chromophore a cell has the more heat that will be absorbed. Therefore laser therapy is quite specific and can be more precise than other therapy choices.

The first laser to discuss would be the carbon dioxide (CO<sub>2</sub>) laser with a wavelength of 10,600nm. It has specificity for water and is therefore taken up by the dermal layers. This laser has increased dispersion of its thermal energy and therefore redness is increased post therapy. An advantage of this dispersion however is the fact that it causes significantly increased collagen production, immediate tightening of the skin and therefore immediate cosmetic results. The laser also has hemostatic properties.

Similar to the CO<sub>2</sub> laser is the Erbium:YAG laser with a wavelength of 2,640nm. This laser is also specific to water however it does not produce the same thermal dispersion as the CO<sub>2</sub> laser. In a study by Newman et al in 1999, 21 upper lips treated with half CO<sub>2</sub> and half Erb:YAG were evaluated. Patients treated with the Erb:YAG laser had significantly less erythema (3.4 days vs 7.7 days) but also significantly decreased cosmesis at 2 months (54% compared to 63%). Given these results the study favored the use of CO<sub>2</sub> laser especially in patients willing to weak make-up while the erythema persisted (11).

Although the remaining lasers are not used for skin resurfacing it is important to mention them as they can be important for cosmesis. The Nd:YAG laser has a wavelength of 1,064nm, is

infrared, and is specific for the chromophore oxyhemoglobin. It has deeper penetration than the CO<sub>2</sub> and Erb:YAG lasers and it is indicated for treatment of telangiectasias, capillary hemangiomas, and port-wine stains. The KTP laser with a wavelength of 532nm is visible and also specific for oxyhemoglobin. It is good for cutaneous vascular lesions. The argon laser is a visible blue light with a wavelength of 193nm. It has depth of penetration between the Nd:YAG and CO<sub>2</sub> laser and is used for similar indications as the Nd:YAG laser. Finally we have the flashlamp excited pulsed dye laser that is a yellow visible laser with a wavelength of 595 nm. Again this is useful for cutaneous vascular lesions but has the added benefit of decreased hypo pigmentation and scarring compared to the Argon and Nd:YAG lasers.

In 2002 Bisson et al looked at the usefulness of lasers and their long term effects. They showed that at 6 weeks wrinkle reduction was achieved in 91% of patients and at 2 years this effect was still seen in 87% of patients (12). Although such good results are commonly seen, the erythema and time spent performing the procedure seems to be its limiting factor. In 2001, Trelles et al looked at patient satisfaction following laser skin resurfacing and found that although 88% of patients were happy with the cosmetic outcome, 77% would not have it performed again if they had the chance (13). Therefore the swing seems to be moving more towards other therapeutic modalities as several studies have shown similar results comparing dermabrasion to laser therapy (14-16). Laser therapy, however, is still very useful in the periorbital and perioral region where dermabrasion is limited

Complications of laser therapy and dermabrasion are similar and will be discussed together. Infection, either bacterial or fungal, is probably one of the most common complications occurring in 4.3 to 12% and 1.8 to 2.2% of patients respectively (17). These numbers include patients treated with antibiotic prophylaxis. Herpes virus risk is also substantial even in patients who have never had an outbreak before. In 1997 Roberts et al evaluated their experience with 907 patients and found that the incidence of post-therapy HSV infections decreased from 3% to 1% with antiviral prophylaxis (18). Therefore patients usually treated with antivirals for 2-3 days prior to therapy and then 2-10 days post therapy to prevent infection.

Other complications are hypo or hyperpigmentary changes commonly seen with patients with melasma, chloasma, and darker skinned patients (Fitzpatrick category 3-6). Melasma and chloasma are associated with oral contraceptive use and pregnancy respectively. Patients should be treated with sunscreen and sun avoidance both pre and post therapy to prevent pigmentation changes (19-20). Milia is a superepidermal cyst that can develop on the malar surfaces and eyelids. These are treated with mild abrasive cleansers or can be derroofed with an 18 gauge needle. Occlusive dressing for 2 weeks post therapy can decrease their occurrence. Isotretinoin preparations should not be used within 6 to 12 months either before or after treatment as it damages pilosebaceous units and therefore inhibits re-epithelialization leading to increased scarring risks (21).

## **Chemoexfoliation**

Another option for facial rejuvenation is chemoexfoliation known better as a chemical peel. The idea behind chemical peels is to wound the skin in a controlled manner to promote new collagen formation and re-epithelialization for a more youthful appearance. As discussed earlier, photodamage increases the thickness of the stratum corneum, decreases the thickness of the

stratum granulosum, decreased collagen and elastin maturation and organization, and also leads to disorganized melanin deposition.

There are different damaging levels that can be obtained with a chemical peel and it is important to understand the effects of such peels at different depths of the skin. Peels that damage the stratum corneum will only smooth the skin due to debridement of the keratin layer. Peels extending down to the basement membrane also will help reorganize pigment and melanin since melanocytes live in the basal layer of the epidermis. Damage into the upper reticular dermis will smooth and lighten the skin but also increase collagen, elastin and GAG production leading to reduction in fine wrinkles. Peels down to the mid reticular dermis will produce an even more robust collagen formation reaction to help get rid of deep rhytids. Finally, peels that extend down in the deep reticular dermis or subcutaneous tissue will often times lead to scarring due to overactive collagen formation and poor re-epithelialization.

Factors that influence the depth of penetration of chemical peels exist and can be used to tailor each therapy for the individual patient. First, with the exception of phenol, the stronger the solution concentration, the deeper the peel penetrates. Because high concentrations often lead to worse outcomes due to toxicity or overtreatment, other modalities are used to help increase penetration without increasing the solution concentration. Pre-peel cleansing with sepiisol and acetone, prolonged time of contact, rubbing or scrubbing the chemical into the skin and even application of occlusive tapes are all examples used to increase penetration. Patient factors that may inadvertently increase solution penetration are recent electrolysis, surgery, or waxing. These events are important to tease out in the history in order to plan appropriately for the depth of therapeutic intent.

Given the large amount of patient factors that exist, each person responds to a chemical peel differently. Each patient has a different thickness of skin, collagen formation capacity, and scarring risk. Therefore, some argue that pre-treatment of the skin in an inconspicuous area is important before treating the entire face. This will help identify how each patient responds to a given treatment and will help guide further therapy.

Regardless of patient differences, each patient is encouraged to cleanse the face regularly, use petroleum jelly as needed to promote moisturized healing, avoid sun and used sunscreen to prevent pigmentation problems, and perform proper wound care post therapy to prevent infection. Again patient selection is very important especially because facial peeling can be quite disfiguring. Patients need to be psychologically ready to cope with their post treatment appearance, be willing to follow up closely, and be patient with the healing process as it can be prolonged with chemoexfoliation.

The actual process of chemoexfoliation is threefold. First is the preparation stage where the skin is cleansed with sepiisol and acetone to remove the superficial layer of oil and keratin that has been built up. Jester's solution or low concentration glycolic acid peels can also be used to thin the epidermis and help the main chemical peel penetrate more deeply (8).

After the skin is clean the chemical peel is applied in a systematic manner for uniformity. Superficial peels will produce a blotchy white and red skin discoloration, medium peels will produce skin with a white center and peripheral erythema, and deep peels will produce a pasty

white skin with no erythema present. Being able to identify this during therapy helps you know if you are achieving your planned depth of treatment.

Once the patient has been treated they will usually begin to exfoliate and desquamate within 2 days and this will continue for up to a week or more depending on the depth of peel. Cool saline presses are applied to the face to prevent inflammation. Vinegar soaks are utilized every 2 hours while the patient is awake for 5-7 days to cleanse the skin and prevent infection. Close follow up is necessary to ensure that infection is not developing and that proper healing is occurring.

Next we will discuss the different options for chemical peeling starting with the least damaging.

### **A. Tretinoin**

Tretinoin is a cream that is often times used as first line therapy for photoaging. It has the advantage of decreasing the thickness of the stratum corneum, increasing the thickness of the stratum spinosum, evening out pigmentation irregularities and smoothing the skin. Disadvantages include pregnancy class C preparation, increased photosensitivity, and it significantly dries out the skin. It is often times used in conjunction with alpha hydroxy acids that potentiate the effects of tretinoin. Alpha hydroxy acid preparations are often found in over the counter creams which can be used to also treat the drying effects of tretinoin.

### **B. Superficial Peels**

The most common superficial peel is trichloroacetic acid (TCA) at a 10% concentration, but Jessner's solution (lactate + salicylate + ethanol + resorcinol) and glycolic acid can also be used. The solution is usually applied for 1-2 minutes and then washed off with water or a buffered bicarbonate solution. Patients will have a slight stinging sensation, a slight flush, and smooth glowing skin. Patient should have no activity restrictions and many patients will not desquamate. Because this is a mild peel they will be able to have it repeated every week, two weeks, or every month as needed. For peels down to the basement membrane meant to tackle pigment irregularities, slightly stronger concentrations of solutions can be used and these patients will likely desquamate for 2-3 days thus limiting their activities.

### **C. Medium Depth Peels**

Initially clinicians were simply increasing the concentration of TCA to increase the depth of penetration into the skin, however they were finding that concentrations of over 50% lead to increased risk of scarring after therapy (22, 24). Therefore they began combining TCA at 35% with Jessner's or glycolic acid solutions to increase depth of penetration without increasing scar formation. Patients treated with medium depth peels will have skin that turns dark brown and they will desquamate for 4 to 7 days leaving them socially incapacitated. As they re-epithelialize their skin will be pinkish red and this will persist for about 1 month.

## **D. Deep Peels**

The most common deep peel is the Baker-Gordon peel which is composed of phenol, croton oil, water and sepiisol. The solution is agitated prior to application and it is applied to one subunit of the face at a time with 10 to 15 minute intervals between subunits. This application technique is used to prevent over absorption systemically and phenol toxicity. The patient will have immediate frosting of the skin and post therapy occlusive dressings are placed. Constant serous exudate will occur hourly that needs to be cleansed. The patient will have intense swelling and release of epithelium over the next 1-2 days with re-epithelialization taking over 1 week to occur. Very red skin will persist for months and hypo pigmentation is expected.

Complications associated with chemical peels are possible with the most fearful being phenol toxicity. In 2007 Landau looked at 181 patients treated with full face phenol peels and found that even after waiting 15 minutes between facial subunits, 6.6% of patients developed arrhythmias. Increased risk was seen in patients with diabetes, hypertension and depression (23). In order to prevent phenol peel complications patients are treated with sedation, IV hydration to dilute systemically absorbed phenol, and intraoperative EKG monitoring. Other preventative measures are preoperative LFTs and creatinine to ensure that the patient can properly metabolize and excrete the phenol.

Infections are similar to those seen in patients treated with dermabrasion and laser resurfacing. Antibiotic prophylaxis and antivirals are commonly used especially for those with deeper peels. Vinegar washes and proper skin care is vital to prevention. Any non-healing wound need to be cultured.

Pigmentation irregularities are possible after therapy. As stated earlier, those with dark skin and those taking OCPs or who are pregnant are at increased risk. Sun avoidance and sunscreen are important preventative as is hydroquinone. Treatment with tretinoin and alpha hydroxy acids are useful, and repeeling is an option.

Scarring is significantly increased in those treated with accutane within the 12 month pre and post treatment period due to poor re-epithelialization. Post therapy skin infections significantly increase the risk of scarring. Other factors that play a role are previous keloids or hypertrophic scars, previously radiated skin, and skin that has been recently operated on or undermined.

## **Soft Tissue Augmentation**

The art of soft tissue augmentation began in 1893 when Neuber harvested arm fat and injected it into facial defects (24). In the 1900's paraffin injection was introduced but fell out of favor quickly due to adverse granulomatous reactions called paraffinomas. By the 1940's and 1950's silicone had been introduced and was being used widely, but again due to granulomatous reactions and scarring its use fell out of favor by the early 1990's. In 1970's Stanford began using human and animal collagen as an injectable filler and these are still used today (25).

Today research is booming in the area of injectable fillers. Companies are looking for inert, long lasting, abundant low cost, non-carcinogenic, reversible and low immunogenic potential products. Patient demand for these products has risen dramatically as procedures are

performed on an outpatient basis, without surgery, with recovery in 48 to 72 hours, and are lower in short term cost than are surgical techniques. Indications for injectable fillers are traumatic and acne scars, adynamic and dynamic rhytids, lip augmentation and melolabial fold augmentation. Today there are 4 different types of injectables and we will discuss each below.

## **A. Xenografts**

Bovine collagen is the first product in this category and is considered the gold standard to which all others are held. It is dissolved in saline and lidocaine for injection and comes in three different formulations. Zyderm I and Zyderm II (INAMED Aesthetics, Irvine, CA) are the same except the concentration is 35mg/mL and 65mg/mL respectively. They are injected into the upper dermis. Both require overcorrection of the defect because the saline eventually is reabsorbed (26). Zyderm II lasts longer because it has a higher concentration. Zyplast (INAMED Aesthetics, Irvine, CA) on the other hand has the same concentration as Zyderm I but has the longest duration of all three preparations because it is linked to glutaraldehyde to decrease its degradation. It is injected into the reticular dermis since it has a longer duration of action. No overcorrection is recommended with Zyplast.

Pitfalls of bovine collagen injections are most commonly hypersensitivity reactions. Up to 3 to 4% of patients will have positive skin test to the preparation prior to therapy, and it is recommended that patients be re-evaluated at 4 to 6 weeks after skin testing as up to 20 to 30% of patients will have delayed hypersensitivity reactions (27, 28). In addition to hypersensitivity, tissue necrosis (29), foreign body reaction and headache, nausea, and arthralgias (30) are possible after therapy.

Hyaluronic acid is the second form of injectable xenografts. It is a glycosaminoglycan (GAG) and can hold 1000 times its weight in water to increase skin turgor. Overcorrection is not required and because its structure is identical in all species, immunogenicity is quite low. Skin testing is not required and hypersensitivity is less than 1%. Correction with hyaluronic acid lasts 6 to 9 months (31). Hyaluronic acid works by attracting water molecules and fibroblasts to the area of injection in order to increase connective tissue production. One unique property of the product is that although the hyaluronic acid is slowly degraded, the water initially absorbed does not disperse until all of the molecules are degraded. This is called isovolumetric contraction (32). Because of this property, re-injection for further therapy requires less of the drug to obtain desired effects.

There are two preparations, Hylaform (INAMED Aesthetics) and Restylane (Medicis Aesthetics, Inc, Scottsdale, AZ). The Hylaform product is purified from rooster combs and has a few reports of hypersensitivity to avian proteins. It has a shorter lifespan than Restylane because it has a lower concentration (33). Restylane is acquired from culture of equine streptococci and is cross linked with epoxides making its immunogenic potential essentially zero.

Pitfalls to hyaluronic acid are based on depth of injection. If injected into the subcutaneous tissue then it is rapidly absorbed, but if injected too superficially, then painful nodules can persist. The major advantage of hyaluronic acid is that it can be reversed with hyaluronidase if results are less than satisfactory.

## **B. Homografts**

The first two homografts available are human collagen analogues to the bovine preparations. Cosmoderm and Cosmoplast (INAMED Aesthetics) are collagen preparations bioengineered from fibroblasts. They have no antigenicity and therefore require no skin testing providing the major advantage over Zyderm I and Zyplast. On average they last approximately 3- 6 months (26) which is less than that seen with bovine equivalents.

Cymetra (LifeCell Corporation, Branchburg, NJ) is the injectable form of alloderm. Cadaveric skin is freeze dried to remove cells from the skin, but leaves the collagen types IV and VII, in addition to proteoglycans and elastin. It is reconstituted with lidocaine prior to injection and requires no skin testing. The duration of action of Cymetra is 3 to 6 months (34).

## **C. Autografts**

The major autograft used in the past was autologous fat. The advantage was that it had no immunogenic potential and was greatly abundant. The disadvantages included a second operation for harvesting, but also the discrepancy as to how long the substance actually works before being reabsorbed. Studies have shown that non-mobile areas like the malar regions have longer duration of action whereas the glabella has less duration of action given the high muscle concentration (26).

The other autograft worth mentioning is call Isologen (Isologen Technologies, Houston, TX). It is a composed of in fibroblasts from a post auricular skin biopsy. The biopsy is sent off for in vitro culture for 4-6 weeks and is then sent back to the practitioner overnight for injection the next day. Timing is imperative and 3-4 injections are required over a 6 month period. The timing and cost of this procedure makes it impractical but it is still an option. Histologic studies have shown integration of the fibroblasts still present at 6 months post therapy, but further studies are still being conducted (35).

## **D. Synthetic Material**

Silicone is the most notable synthetic material that has a long track history of use. It requires multiple microdroplet injections over 4 weeks and injections are placed in the dermis approximately 1 to 3mm apart. No overcorrection is required because the body encapsulates the product and prevents it degradation. In the 1980's Webster published a paper looking at 235 patients and over 2800 injections (36). He found excellent results and very few complications, but over the years others have reported both benign and severe reactions to the material. Chronic inflammation, migration, extrusion/ulceration, skin necrosis, granulomatous hepatitis, pulmonary emboli, and silicosis are just a few of the documented reactions (37-39). Because of the severity of some of these reactions, the FDA declared it illegal in 1991. Since then the American Academy of Dermatology has supported its use (7), and off label use is likely to return given ophthalmology's success with the product in retinal detachment.

One of the newer and more intriguing synthetic materials is Radiesse (BioForm Medical, San Mateo, CA). It is a hydroxyapatite particle dissolved in water, glycerin and sodium carboxymethylcellulose. It is injected subdermally because of its viscosity and it must be massaged after injection so that it is contoured appropriately. It produces augmentation in two

ways: first it encourages collagen ingrowth by fibroblasts and secondly it is encapsulated by fibroblasts which prevents its degradation. This encapsulation is so strong that it can be radiographically evident for at least 6 years (40). Pitfalls include a palpable implant for 2 to 3 months until collagen replaces it and injection into the lips can produce painful nodules. Tzikas looked at 90 patients treated with Radiesse and found an 88% patient satisfaction rating at 6 months (41).

### **Complications of Soft Tissue Augmentation**

After injection pain, redness, ecchymosis, swelling, nodularity, and palpability are all common findings, but should only be transient with resolution after 1 to 2 days. Persistent complaints lasting more than two days should alert the physician to complications. There are three different time periods during which specific complications can occur. They are reviewed below in chronological order (42).

Immediate complications occur on days 0 to 2. The first complication is overcorrection. Proper knowledge of the filler properties, injection sites, and reversibility is important in the prevention of this complication. Implant Visibility is the second complication in this time period. Hyaluronic acid can produce a bluish nodule and other fillers can produce a white nodule. Massage is the initial treatment to disperse the injected filler, however hyaluronidase or mechanical derroofing of the nodule are second line therapies.

The last complication consists of vascular compromise. Arterial embolization must be treated immediately. It is evident with intense pain while injecting and immediate skin blanching. This is most common in the glabellar region where vasculature is prominent. Treatment includes aspiration, massage, warm compresses, and even 2% nitropaste to aid in vasodilation. Hyperbaric oxygen can also be used should impending skin necrosis be considered. Venous injury is more common with high volume injections. It presents as a violaceous discoloration of the skin with a dull ache. Again nitropaste and warm compresses are used but treatment is less urgent. Any skin breakdown identified during this time period is treated with antibiotics and gentle debridement.

Delayed complications seen on days 3 to 14 include noninflammatory and early inflammatory nodules. Non-inflammatory nodules include observation, gentle massage, and reassurance. Early inflammatory nodules are first treated with tetracycline and/or macrolide antibiotics for 4 to 6 weeks as they are infected until proven otherwise. Any lesions that are fluctuant require incision and drainage and close follow up is required at 48 hours after initiation of treatment. If patients have no response to therapy then it is important to get tissue for culture to direct antibiotic therapy.

Late complications are found after 14 weeks post therapy. Hypersensitivity reactions are possible as in the case of bovine collagen and hyaluronic acid from rooster combs. Nodules that form late can be treated with saline injection for dilution and aggressive massage to break up the filler. Inflammatory nodules this late must be evaluated for infection and treated appropriately. If there is no infection but the nodule persists despite massage and saline injection for 7 to 10 days, then intralesional steroids injection can be used to prevent granuloma formation. If still no

response these lesions are biopsied and sent for culture. Finally, true granulomas are very rare (0.01 to 1%) and massage and steroid injections are the mainstay of treatment.

## **Summary**

Photoaging and adynamic facial changes are events that each of us will experience. Throughout history people have tried to adopt techniques to achieve a more youthful appearance and as of today, there are many options to achieve that goal. Proper knowledge of the products available and consistent technique is vital to performing high quality and complication free aesthetics. Finally patient expectations, informed consent and proper patient selection are paramount to the success of the facial plastic surgeon.

## **Duscussant's Remarks: Michael P. Underbrink, MD**

**That was a very fine talk, Dr. Coughlin and you covered all the injectables very nicely. Here are a couple of points to remember: you are injecting foreign material; and you're always at risk for hypersensitivity reactions after the patient has been injected. This figures in your pre-operative assessment when you're explaining these things to the patient. You did a good job in letting us know the length of these procedures from the standpoint of the patient. You've got to let the patient know that you're going to be re-injecting and it's important to explain what the time frame is after the injections of bovine collagen. You will, of course have explained the complications which can occur with each of these injections.**

**It's technically demanding with a shallow learning curve It does take a lot of experience to inject and not get these complications such as nodules and consequent patient dissatisfaction, much less some of the more serious complications. You did a very good job in describing those. Overall it was a very good talk and a good job.**

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