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Applications and effects of «Cold Atmospheric Plasma» in Aesthetics

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Abstract
Aging is an unavoidable and natural process for all organs. The aging process of the face is a gradual atrophic progression of soft and hard tissues and takes place gradually, over 3 to 4 decades, with a little clinical evidence. It is eventually recognized by the emergence of furrows and wrinkles together with a loss of tonicity. The consequences of this on the patient's self-confidence could negatively influence the quality of life in a psychological and social way. Different techniques have been used for removing or improving the signs of ageing. Currently, a physicochemical approach, based on ionized gases, is joining the skin non-surgical treatments. This technology, named Cold Atmospheric Plasma (CAP), was already used in dermatology to promote wound healing. Today, CAP is entering into the cosmetic field, thus providing a new challenge. In reason of their unique ability to generate a complex chemical mix and thanks to their physical properties, CAPs could be a promising alternative in non-invasive treatment of skin. However, the scientific bases of cold plasma effects on skin and the identification of their exact mechanisms of action, both at the cellular and at the molecular levels, are still lacking and they constitute a new active field of investigation. The present article is a literature review of the applications and effects of «cold atmospheric plasma» in aesthetics.

KEYWORDS
skin, cold atmospheric plasma, RONS, aging, dermatology, facial dermatoaesthetic

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1. INTRODUCTION

Cold atmospheric plasma is an emerging innovative technology known to the scientific community for several years as it has been studied and applied in fields such as engineering, materials science, food and in new fields such as medicine for the treatment of cancer and others and its application in dermatology for the disinfection of the skin and the healing of ulcers. Making a little historical review first William Crookes in 1879 established the basic principles of plasma science by experimentally ionizing gas by applying high voltage in an electric discharge tube and the ionized gas was called radioactive matter. Fifty years later Irvin Lagmuir and Lewi Tonks used the term plasma to describe the ionized gas of an electrical discharge (1). In physics, plasma consists of electrons, ions, photons, metastables, and electromagnetic fields. Nowadays, cold atmospheric plasma (CAP) could be produced at atmospheric pressure and operate under room temperature (2). Use of cold atmospheric-pressure plasmas (CAP), that generate temperatures not higher than 40 °C at the target site of treatment. Among the broad spectrum of technologies to generate cold plasma at atmospheric conditions, two basic types of CAP devices are dominating preclinical and clinical research in plasma medicine: dielectric barrier discharges (DBD) and plasma jets (3).

2. DISCUSSION

There have been several in vitro studies in the last few years focusing on the effect of CAP exclusively on non-diseased skin cells and these projects mostly used HaCaT human immortalized keratinocytes as the cellular model. Although there were some variations in plasma-induced cellular changes, it was found that the respective change at the cellular level was also reflected correspondingly at the protein level and gene level [2]. Lately some CAP devices have been developed for skin regeneration. These plasma sources, operating with atmospheric air, nitrogen or argon, can reach temperatures higher than 60 °C and are mostly used in skin resurfacing. Like laser resurfacing, this type of cosmetic plasma treatment is mostly used to burn the outer layers of the skin and force its renewal [4]. Plasma treatments work by a mechanic ablation of the dead outer skin layers. Some recent evidence suggest that mild CAP treatments may actually stimulate the deeper layer of the skin and play an anti-age role on skin cells. Treatment with low-temperature plasma increased the expression of anti-aging genes in skin cells, including collagen, fibronectin and vascular endothelial growth factor [5].In the active forms of oxygen / Reactive oxygen species ROS, O3, produced mainly by the cold atmospheric plasma / Cold atmospheric plasma (CAP) fed by air also contributes to the induced by plasma biocidal action (6). Numerous studies, it has been demonstrated that using cold atmospheric plasma (CAP) improves the oxygenation of the underlying tissue. Increased temperature (between 30 and 40 °C) and NO produced directly or indirectly by CAP may be to blame for this [7].

Plasma skin regeneration (PSR) is a novel method of resurfacing that uses plasma energy to create a thermal effect on the skin, leaves a layer of intact, desiccated epidermis that acts as a natural biologic dressing and promotes wound healing and rapid recovery. The safety profile of PSR is excellent, and there have been no reports of demarcation lines in perioral, periorbital, or jawline areas, as can sometimes be observed following CO2 resurfacing. PSR is effective in improving facial and periorbital rhytides and can be used on non-facial sites, including the hands, neck, and chest. Histological studies performed on plasma resurfacing patients have confirmed continued collagen production, reduction of elastosis, and progressive skin rejuvenation beyond 1 year after treatment [8]. Published reports assessing high energy (3-4 J) single pass PSR for facial rejuvenation have demonstrated a mean 50% improvement in skin tone 30 days after treatment. Other reports have shown attenuated clinical improvement over time, e.g., a mean 39% reduction in depth of fine facial lines at 10 days after treatment that decreased to 23% 6 months after treatment (9) Another study has shown objectively that PSR produces a long-term condition in depth of facial irregularity, along with minimal postoperative sequelae/morbidity. Fine line depth reduction was maximal at 10 days (39%), with an attributable cause from edema: this depth reduction decreased to 24% at 6 months (10).

The voltaic arc dermabrasion has shown to be effective for skin tightening and improving periorbital rhytides. The application of the voltaic arc energy is well tolerated clinically and allows for effective improvement of skin laxity and rhytids. The voltaic arc causes rapid heating of the skin with limited tissue ablation and minimal collateral thermal damage (11). Voltaic arc dermabrasion (PLEXR, GMV, s.r.l. Grottaferrata, Italy) were used to remove the keratinized layer for point perioral area. The authors treated 34 patients (26 women and 8 men) for perioral rhytides with voltaic arc dermabrasion technique. Patient ages ranged between 30 and 65 years and the majority (90%) of these perioral areas had class II and III wrinkle scores. Treatments are minimally painful and in the authors experience require no anesthesia. No discomfort should be expected. The voltaic arc acts without getting in tip –tissue contact, creating a gentle coagulation. There is no electric passage zone; for this reason, the dermabrasion is not influenced from the tissue electric resistance. In response to injury, fibroblasts in the papillary dermis increase production of type I and type III procollagen in addition to transforming growth factor beta-1 (TGF-β) [12]. Another field in which it was studied is periauricular lines. These lines appear around the ear region and rarely studied because they are close to the ears, and for this reason, they are not visible when viewing the face in a frontal view but only when the face is viewed laterally. The authors treated 80 patients (56 female and 24 male) for excess periauricular lines and the keratinized layer in the periauricular area was removed using voltaic arc dermabrasion (VAD, Europe Medical srl, Montesilvano (PE), Italy). It causes a temperature increase in the skin with ablation of a small superficial tissue layer and contraction of collagen. All patients displayed with some degree of tissue contraction that it stretched the lax skin of the periauricular lines, resulting in cosmetic improvement. Also induces a slight skin retraction and elevates the periauricular skin in the majority of patients, providing a further cosmetic advantage (13).

Another research has shown that voltaic arc dermabrasion plasma successfully removes nasal telangiectasia: there were no important or permanent complications, no recurrence rates, and the good aesthetic results improved the appearance of the nasal area (14).

Also, the effect of CAP on tissue regeneration has also been elucidated for its potential in scar treatment. In one study, ten patients with acne scars received a single CAP treatment using a Plasma Skin Regeneration (PSR) system. According to patient and doctoral assessment, acne scars improved in 30% of the patients. Thermal damage to the epidermis and upper dermis had been observed for four-six days, and besides that, collagen remodeling effects without permanent pigmentary or textural irregularities as well as regenerative epidermal effects have been described (15).

3. CONCLUSION

Cold atmospheric plasma techniques have emerged in recent years as new powerful tools in various fields of medicine, from oncology to dermatology. The ability to produce plasma under atmospheric pressure was the basis for the rapid development of plasma-related applications in biomedical sciences. Cold Atmospheric Plasma contains a number of active ingredients such as charged particles, electricity, UV radiation and active types of gases that can act together, as antipruritic, antimicrobial, anti-inflammatory, tissue stimulants and blood flow enhancers, as proved at in vivo and in vitro experiments and to date, no resistance of pathogens to cold atmospheric plasma therapy has been observed. The combination of different active agents and the wide range of their positive effects in various diseases, especially in easily accessible skin diseases, makes cold atmospheric plasma quite attractive for applications in medicine. There are two type sources of cold plasma production for use in biomedical sciences: indirect (plasma launch) and direct (DBD barrier evacuation). Considering the flexibility of plasma production, thanks to its many parameters, could be a new and promising treatment for its care and regeneration skin. This will lead to a continued optimization of the devices, regarding the effectiveness, control and safety of their use, as well as through it of deciphering the mechanisms involved in the effects caused by the plasma on the skin. This innovative technology opens up new areas of research in interface between plasma physics and skin biology and is expected lead to new applications in the field of dermatoesthetic interventions.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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