



Figure 6. The situation after three days of pharmacological therapy.



Figure 7. The extraoral situation after one month: the ecchymosis and swelling appeared fully resolved.

The subject gave informed consent, and the study was therefore performed in accordance with the ethical standards of the Declaration of Helsinki (as revised in Brazil 2013).

## Discussion

Surgical procedures are not the only cause for development of subcutaneous emphysema, as cases have been described during restorative, crown and endodontic procedures. Emphysema also has been reported during oral laser surgery. Air can be introduced into the soft tissue spaces by several routes, but it usually passes through the dentoalveolar membrane or a root canal (9).

In accordance with recent studies, the efficacy of the sodium hypochlorite solutions depends on its concentration. A previous study evaluated the efficacy *in vitro* of three different concentrations of NaOCl against *Enterococcus faecalis* (10). This study demonstrated the higher efficacy of the highest concentration used (5.25%). The correlation between concentration and antimicrobial action is confirmed as well. The efficacy of sodium hypochlorite antimicrobial action also depends on its pH, its osmolarity, its flow through the root canals, its quantity and time of persistence in the canals (11).

Alongside its antimicrobial activity, sodium hypochlorite is an extremely cytotoxic chemical solution (11). In fact, when it gets into contact with vital tissues, NaOCl causes a whole series of diseases such as haemolysis, ulceration, inhibition of neutrophil migration, damage to endothelial and fibroblast cells, facial nerve weakness, and necrosis. These toxic effects can occur because of this solution alkalinity (pH 10.8-12.9) and the hypertonicity of oxidating proteins and lipid membranes (12, 13).

Human tissues exposed to NaOCl solution can be affected by subcutaneous emphysema, which is a condition characterized by the presence of air in the tissues under the skin due to oxygen liberation into the same tissues.

When subcutaneous emphysema occurs, the patients report severe pain, ecchymosis and swelling. Some patients report temporary nerve paresthesia as well. The swelling can occur in different areas according to the tooth involved. If the sodium hypochlorite extravasation occurs in an upper tooth, the swelling can affect the maxillary upper part, comprising the eye, the maxillary sinus, the wing of the nose and the cheek. Otherwise, if the tooth involved is mandibular, the swelling can extend to the cheek, the angle of the mandible and, in the worst cases, the ear and the neck.

Most of these cases arise because of incorrect determination of the working length or canal anatomical anomalies such as reabsorption or open-apex, lateral perforation and iatrogenic widening of the apical foramen. Many subcutaneous emphysema cases are caused by use of positive pressure irrigation with a

wide-gauged and apical-opened needle (14). Professionals in this line of work must be careful about how far the irrigating needle is placed into the canal. This can prevent irrigation accidents. Any needle should either be bound in the canal or applied in the proximity of the working length. A gentle flow rate should be used to avoid extravasation. Using a Luer-Lock lateral-opened needle is also advised (15, 16). Recent studies have suggested the use of an EndoVac irrigation system to obtain safe irrigation throughout the working length. Nielsen and Baumgartner's study in fact pinpoints the use of an EndoVac system resulting in statistically significant more debris removal at 1 mm from the working length than needle irrigation with a downturn in extravasation accidents (17).

It is important to know the working length and to be certain about the integrity of the root canal system before irrigating with any concentrated solution (17). Some advantages in the decontamination of the root canal system can be provided also by laser devices, which have been described by the Authors of previous studies. In fact, the use of KTP laser and a 980-nm diode laser revealed statistically highly significant differences ( $P \leq 0.01$ ) compared to traditional endodontic procedures in the reduction of the load of *Enterococcus faecalis* biofilms (higher than 96 and 93%, respectively) (18, 19).

Although providers perform an adequate endodontic therapy, if a subcutaneous emphysema arises, professionals should first and foremost apply an ice-pack on the involved part. Second, they should administer antibiotics, analgesics and cortisone-based therapy, if needed. These actions will help to control the inflammatory reaction (20).

## Conclusion

This paper report investigates a case in which extrusion of NaOCl caused severe tissue damage when unintentionally injected beyond the root canal foramen. Side effects include pain, ecchymosis and swelling of the face. Determining the correct working length, even when performing an intraoperative peri-apical radiograph and confirming the root canal integrity, could help avoid these kinds of accidents. Lower concentrations of NaOCl may be helpful, and using a negative-pressure system of irrigation, such as an Endo-Vac, could help to properly perform endodontic treatment.

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