HOW TO INTEGRATE SIMULATION IN TRAINING FOR MAXILLOFACIAL SURGERY RESIDENTS?

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Abstract

Introduction: Simulation is a novate educative process that replaces interaction with real patients by interaction with artificial models, actors or virtual patients. Thanks to postgraduate reforms in France, surgical learning is reconsidered in each surgical speciality. E-learning and simulation have to be included at each step of the teaching. The aim of this study is to identify how simulation could be included in educative goals for maxillofacial surgery and to propose this review to the French College of maxillofacial surgery.

Materials and methods: We reviewed the list of educative goals of the residents' teaching to identify those that could be taught with simulation techniques. We researched on PubMed studies about these educative goals and simulation. “simulation”, “maxillofacial procedures” and “training” were used for key words. Article with an abstract in English or French were considered. We also researched training article for each maxillofacial goal to compare usual teaching and simulation or virtual reality.

Results: We identified 7 goals in the base cycle and 6 in the deepening and consolidation cycles that could be taught with simulation techniques. 95 articles were selected with these 3 keywords. 21 were included in our study. No study about microsurgery, tracheotomy and anatomy was found with this keyword research. We found studies about these goals with specific research extended to other surgical speciality.

Discussion: Despite the development of simulation and virtual reality in surgery training notably in USA, these innovative techniques are not much used today for French maxillofacial residents’ training. The ongoing postgraduate reform offers a valuable opportunity to reconsider how we would like to teach maxillofacial surgery. Because of reduced time for teaching and highly demanding skills, simulation tools appear as great-value options to complete conventional approaches.
Introduction:
Historically, residents learned surgical technics on medical books, human cadaveric dissection and in operating room with a supervisor (Gosh et al. 2015). However, this traditional form of training questions about didactic efficiency (Desender et al. 2001). Simulation is a novate educative process that replaces interaction with real patients by interaction with artificial models, actors or virtual patients (GABA et al, 2004). The combination of an ever-reducing allocation of time in workplace training with highly demanding skills has led to the establishment of simulation as an integral part of surgical training. Mastering these skills cannot be achieved only through observations, as it requires a significant amount of dexterity and must be practised regularly.

The French National Academy in Medicine and Surgery recommends since 2005 a surgical learning including medical school lectures, practical training in patient care and in the operating room and, thirdly, virtual reality training with simulators (Hollender et al., 2005). Since 2010, HAS, The French National Authority of Health, works on simulation and e-learning in surgical training and edit some specific recommendations (HAS, best practice guide for simulation, 2012). Even if the notion of simulation for training is not new, the learning techniques through simulation have increased in recent years because of the development of laparoscopy and other new technologies like 3D printer (Breaud et al., 2012).

Thanks to postgraduate reforms in France, surgical learning is reconsidered in each surgical speciality. E-learning and simulation have to be included at each step of the teaching.

The aim of this study is to identify how simulation could be included in educative goals for maxillofacial surgery and to propose this review to the French College of maxillofacial surgery.

Materials and methods
During the postgraduate reform of 2017, the College of maxillofacial surgery in France established a list of educative goals for resident in base (first year), deepening (next 3 years) and consolidation cycle (last internship year). The goals of the first year of internship (base cycle) are based on fundamental concept in medicine (patient relationship, anatomy). After this first year, residents have to be efficient for more and more complicated procedures.

We reviewed the list of educative goals of the residents’ teaching to identify those that could be taught with simulation techniques.

We also researched on PubMed studies about these educative goals and simulation.
“simulation”, “maxillofacial procedures” and “training” were used for key words. Article with an abstract in English or French were considered. We also researched training article for each maxillofacial goal to compare usual teaching and simulation or virtual reality.

Results
We identified 7 goals in the base cycle and 6 in the deepening and consolidation cycles that could be taught with simulation techniques (Table 1).

95 articles were selected with these 3 keywords. 21 were included in our study. 74 were excluded. These studies were excluded because no abstract was available or presented training not for resident. We excluded also studies about 3D planner to prepare difficult operation for graduate surgeon. No study about microsurgery, tracheotomy and anatomy was found with this keyword research. We found studies about these goals with specific research extended to other surgical speciality.

Table 1: Goals identified in base, deepening and consolidation cycle and interest with over speciality

<table>
<thead>
<tr>
<th>Goal</th>
<th>Mutual goal in other surgical speciality</th>
</tr>
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<tbody>
<tr>
<td><strong>Base cycle</strong></td>
<td></td>
</tr>
<tr>
<td>Tracheotomy</td>
<td>ORL</td>
</tr>
<tr>
<td>Cardiac arrest care</td>
<td>All speciality</td>
</tr>
<tr>
<td>Respiratory distress care</td>
<td>All speciality</td>
</tr>
<tr>
<td>Announcement of a death</td>
<td>All speciality</td>
</tr>
<tr>
<td>Announcement of a cancer</td>
<td>All speciality</td>
</tr>
<tr>
<td>Anatomy</td>
<td>ORL, plastic surgeon, neurosurgeon</td>
</tr>
<tr>
<td>Sutures, local skin flap</td>
<td>ORL, plastic surgeon</td>
</tr>
<tr>
<td><strong>Deepening and consolidation cycle</strong></td>
<td></td>
</tr>
<tr>
<td>Upper airways endoscopy</td>
<td>ORL</td>
</tr>
<tr>
<td>Craniofacial fractures</td>
<td>Neurosurgeon, plastic surgeon</td>
</tr>
<tr>
<td>Orthognatic surgery</td>
<td></td>
</tr>
<tr>
<td>Cleft lip repair</td>
<td>Plastic surgeon</td>
</tr>
<tr>
<td>Microsurgery</td>
<td>All surgical speciality</td>
</tr>
<tr>
<td>Implantology</td>
<td>Dentist</td>
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</tbody>
</table>
Emergency care (cardiac arrest, respiratory distress):
Introduction of training to critical life-threatening emergency situations on high-fidelity patient simulators seems to be very efficient in medical or dental students (Roy et al., 2017; Onan et al., 2017). Simulation platforms offer scenarios for emergency care and dummies that can help improve critical time management, decision-making, communication and handover between medical and paramedical actors (Annex 1).
A serious game like Staying Alive could be proposed for maxillofacial resident in partnership with nurse student to improve communication and cooperation.

Relationship with patient (announcement of a death or cancer)
Empathy is a fundamental quality in therapeutic relationship and is very important for therapeutic adherence. Teaching empathy to medical or nurse students demonstrates its effectiveness (Batt-Rawden et al., 2013; Bas-Samiento et al., 2017). We propose to develop scenarios with actor especially about announcement of a death or a cancer (Annex 2).

Anatomy
Craniofacial anatomy is very complex to understand because of internal spaces and cavities and the presence of a lot of bones, muscles and vessels closely interlinked. Students also face difficulties to understand craniofacial fractures. In perineal anatomy, 3D virtual simulator combined with an anatomic dummy demonstrated a better understanding (Legendre et al., 2014). In maxillofacial surgery, no anatomical virtual simulator is available. Students learn on CT-Scanners or on medical books. Dr Hossein Khonsari (maxillofacial surgeon) and Donatien Aubert (doctoral student in numerical art) are about to develop an anatomical virtual project with ILUMENS platform (Picture 1). Student will be able to walk through a real skull with and without fractures.
Picture 1: 3D virtual reality project develop by R. Khonsari and D. Aubert. With patient’s CT scan, they created a virtual skull representation. Student could walk through the skull and visualise anatomy or carniofacial fractures.

**Tracheotomy**
No efficient virtual simulator model for tracheotomy was found in this review. A study about ovine model demonstrated that fresh ovine tissue is anatomically compatible for training (Ianacone et al., 2016). At this time, human cadaveric dissection is the gold standard but ovine model must be taken into account because of availability and affordable price as compared with human model.

**Sutures and local skin flap**
Usually, residents learn suture on animal tissue or on human cadaver. A virtual simulator could be a more affordable and repeatable solution. In a pioneering article on the subject, Pieper et al. were the first to describe the use of the finite element method to simulate local skin flaps (Pieper et al., 1995). Over time, simulators became more and more realistic and included haptic feedback (Mitchell et al., 2016, Picture 2). At the beginning of the internship, teaching local skin flap with a surgical simulator seems to be an ethical and affordable alternative to human cadaver.
Upper airways endoscopy

Upper airways dummies (Woo et al., 2017) and virtual reality simulators (De Oliveira et al., 2013, picture 3) have been developed for E.N.T and anaesthesiologists needs. They could easily be adapted to teach upper airways endoscopy to maxillofacial residents.

Craniofacial fractures or reconstruction

Surgeon must be very careful to apply appropriate forces and operate at appropriate speeds in maxillofacial procedures. Inexperienced surgeons need a long-time practice to learn how to minimize the risks caused by the uncontrolled contacts and cutting motions in manipulation of instruments with high-speed reciprocation or rotation.
High-fidelity visual and haptic feedbacks are provided to enhance the perception in a realistic virtual surgical environment. A lot of maxillofacial training simulators have been developed to apply appropriate forces for drilling, milling or sawing with efficient results (Wang et al., 2012; Schartzman et al., 2014; Lin et al., 2014; Hollensteiner et al., 2017; Lichtenstein et al., 2017; Picture 4a)

Specific virtual simulators with or without haptic feedback were also developed for orbital reconstruction (Khelemsky et al., 2017) (Picture 4b)

Picture 4a: simulator with virtual reality and haptic feedback for maxillofacial fractures management training.

Picture 4b: a virtual training on Iphone or Ipad for orbital floor defect training.
**Orthognatic surgery**

Like maxillofacial fractures, simulation in orthognatic surgery is important to develop surgical skills. Training simulators with virtual reality and haptic feedback (Picture 5) were created for bilateral split osteotomy (Sofronia et al., 2013) and for Le-Fort I osteotomy (Wu et al., 2014). Combined with maxillofacial fractures and orthognatic surgery, a training simulator with different surgical techniques seems to be a positive and great-value investment.

![simulator for Le-Fort 1 procedure with haptic feedback (a) and virtual reality (b)](image)

**Microsurgery**

Studies demonstrated that the competency of residents improves to a level comparable to that of experts after intensive repetition of anastomoses over a relatively short space of time, which is inversely proportional to the previous experience of the trainee (Lascar et al., 2007). Usually, residents in surgery learn microsurgery during a specific university degree. They use different simulation models with low-fidelity (surgical gauze, rubber glove...) or high-fidelity like human cadaveric or alive animals. Studies showed that low-fidelity models were a good great-value simulator for beginner residents and cadavers or alive animals have to be reserved for more experimented residents (Evgeniou et al., 2017). A human vascularised and ventilated cadaver (simLife, Delpech et al., 2016) was created to learn surgical procedures in a better realistic simulation context, but this model is expensive (2,000 euros per student). If this model is to be used in maxillofacial resident training, it has to be reserved for very last simulation and evaluation.
Implantology
Many simulators were developed for dentist training. For maxillofacial resident goals, we can use simulators developed for implantology. The ideal training combines 3D planning (like Simplant) and a simulator with virtual reality and haptic feedback (Afshari et al., 2017). A collaboration with the Faculty of Dentistry could help reduce costs.

Cleft lip repair
Cleft lip repair is a very careful procedure. Usually, students train on photos of faces to identify the anatomical landmarks of the cleft lip. But this technique excludes 3D topography and depends on photo quality. Zheng et al., 2015 offered an interesting silicone cleft lip model to draw anatomical landmark and training on incisions and surgical techniques, Picture 6.

Picture 6: silicone cleft lip model before and after training surgery.
Discussion

Despite the development of simulation and virtual reality in surgery training notably in USA, these innovative techniques are not much used today for French maxillofacial residents training. The ongoing postgraduate reform offers a valuable opportunity to reconsider how we would like to teach maxillofacial surgery. Because of reduced time for teaching and highly demanding skills, simulation tools appear as great-value options to complete conventional approaches.

The medicolegal and economic impact of simulation training prior to certification in certain specialties or for “high risk” techniques is now well-recognized (Gallagher et al., 2004). Moreover, patients may feel reassured to know that their surgeon has trained on a simulator before performing an invasive procedure on their body (Graber et al., 2005).

With time, simulation training could become a medicolegal certificate to perform specific procedures or to evaluate residents. Investment could also be beneficial for younger medical students (anatomy, sutures, 3D fractures reconstruction) or for graduated surgeon in ongoing training.

Thanks to progress on haptic feedback and graphic resolution, simulators are a more efficient tool to surgery training.

However, not many comparative studies were published specially in maxillofacial surgery. Ioannou et al., 2015 found that oral surgical technique training on a simulator is similar that training on an ovine setting. More comparative studies and research with cost-benefit analysis are required.

Whatever the final choice of the college of maxillofacial surgery, this education programme has to be evaluated on resident satisfaction and profit for surgical skill acquisitions.


HAS, guide de bonnes pratiques en matière de simulation de santé, 2012


**Nom du scénario : Annonce d’un cancer**

<table>
<thead>
<tr>
<th>Objectifs pédagogiques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Médicaux</td>
</tr>
<tr>
<td>Empathie</td>
</tr>
<tr>
<td>Information claire et simple</td>
</tr>
</tbody>
</table>

**Briefing général :**
Un patient de 55 ans alcool-tabagique, vous a consulté la semaine dernière pour une ulcération endobuccale qui ne cicatrise pas depuis 1 mois. La lésion est ulcéro-bourgeonnante et vous décidez de réaliser une biopsie. Vous revoyez votre patient au bout d’une semaine avec les résultats. Il s’agit d’un carcinome épidermoïde de haut grade. Vous devez lui annoncer le diagnostic et la suite de la prise en charge.

**Formateurs, apprenants et rôles**

Débriefing : …avec les formateurs (chirurgiens maxillofaciaux qualifiés, psychologue)

Nombre d’apprenant : …1……………………………………………………………………………………………………………………………

Acteurs : ………2……………………………………………………………………………………………………………………………

**Préparation de la salle**

*Environnement type : un bureau, trois chaises (une pour le médecin, deux pour patient et un accompagnant, sa femme)*

*Le dossier médical*

*La feuille de résultat de l’analyse anatomopathologique*

*Telephone*
Fiche acteur patient

• Nom, âge, sexe : Roger Dupont, 55 ans
• Comportement et état émotionnel : angoissé
• Contexte social, professionnel, habitudes de vie
  Alcool : 3 verres par repas
  Tabac : 1 paquet par jour depuis 30 ans, 30 PA
• ATCD particuliers :
  Fracture de la cheville il y a 3 ans
• Idées que le patient se fait du problème actuel
  – Inquiet ? oui
  – Impact sur sa vie ? oui
  – Attentes envers la prise en charge
    Peur du cancer, de la chimio surtout
• Interactions avec les autres membres présents lors de la simulation (femme)
  La femme pose beaucoup de question. Le mari reste assez mutique
• Mise en œuvre du jeu de rôle
  – Jean et chemise à carreaux pour le mari
  – Robe à fleur pour la femme
• Fils conducteur du scénario
  – Indices attendus/à donner
    3 informations :
    – Cancer
    – Bilan d’extension
    – RCP pour meilleur traitement : chirurgie ou radiothérapie ou chimiothérapie
– Phrases précises attendues par le médecin :
– Cancer de la bouche au début du scénario
– Bilan à la recherche d’autre localisation :
  Scanner
  Panendoscopie= aller regarder dans toute la bouche jusqu’à l’entrée de l’œsophage sous anesthésie générale
– Avec tous ces résultats, réunion avec plusieurs spécialistes pour savoir quel est le traitement le plus adapté à la situation de monsieur
– Traitement possible : chirurgie, radiothérapie, chimiothérapie
– Consultation infirmière pour refaire le point à proposer en fin de consultation

– Fin du scénario
  Vous allez refaire le point avec une infirmière du service. N’hésitez pas si vous avez des questions à lui poser ou lui demander de revenir vers moi.

Déroulé du scénario

Accueil
le médecin doit débrancher le téléphone

Annonce du diagnostic, le patient est mutique, sa femme pleure et vous demande si il va mourir ?
A quoi cela est du ?

Explications du bilan d’extension
RCP
Traitement possible

A la fin de la consultation, le patient vous demande si c’est grave. Si il sera encore là à Noel ? (nous sommes en Aout)
Phrases simples et mots simples
ne pas faire utiliser de jargon médical