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TransOral Robotic Photodynamic Therapy for the Oropharynx

Harry Quon, MD^{1,2,3}, Jarod Finlay, PhD^{1,3}, Keith Cengel, MD^{1,3}, Timothy Zhu, PhD^{1,3}, Bert O'Malley Jr., MD^{2,3}, and Gregory Weinstein, MD^{2,3}

¹Department of Radiation Oncology

²Department of Otorhinolaryngology – Head and Neck Surgery

³University of Pennsylvania

Abstract

Photodynamic therapy (PDT) has been used for head and neck carcinomas with little experience in the oropharynx due to technical challenges in achieving adequate exposure. We present the case of a patient with a second right tonsil carcinoma following previous treatment with transoral robotic surgery (TORS) and postoperative chemoradiation for a left tonsil carcinoma. Repeat TORS for the right tonsil carcinoma reviewed multiple positive surgical margins. The power output from the robotic camera was modified to facilitate safe intraoperative three dimensional visualization of the tumor bed. The robotic arms facilitated clear exposure of the tonsil and tongue base with stable administration of the fluence. Real-time measurements confirmed stable photobleaching with augmentation of the prescribed light fluence secondary to light scatter in the oropharynx. We report a potential new role using TORS for exposure and accurate PDT in the oropharynx.

Keywords

transoral robotic surgery; Photofrin PDT; oropharynx

Clinical Case

We present a 46 year-old otherwise healthy male with a 20 pack year cigarette smoking history who presented with a recurrent right tonsil carcinoma and previously treated for a separate left tonsil carcinoma with transoral robotic surgery (TORS) and postoperative chemoradiation to both sides of the neck and the primary site. TORS exploits the tremor filtration, motion scaling and high definition 3-dimensional optics of robotic arms with distal interchangeable wristed instruments which when placed intraorally facilitate improved

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Harry Quon, MD, Hospital of the University of Pennsylvania, Department of Radiation Oncology, 3400 Spruce Street–2 Donner, Philadelphia, PA 19104, Phone: 215-614-0392, Fax: 215-349-5445, quon@xrt.upenn.edu.

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surgical access to the oropharynx. Up to 4 robotic arms are available with one providing a xenon light source. Repeat TORS for the right tonsil carcinoma revealed a 2.5 cm carcinoma with multiple focal positive margins which was felt to be superficial in depth but diffuse (Figure 1). Photodynamic therapy was felt to be the appropriate adjuvant treatment. Photofrin® (2mg/kg) was administered intravenously 48 hours prior to being brought to the operating room. The time interval was chosen to favor cellular rather than vascular targeting as the target was a potential devascularized surgical bed with prior radiation exposure. The treatment light field was set to cover the extent of visible disease, resulting in a 5-cm diameter field as measured on the tissue surface. It was anticipated that the fluence rate at the surface would be higher than the incident irradiance due to multiple scattering (integrating sphere effect) (1). Therefore, a conservative prescription of 75 J/cm² at 100 mW/cm² to a 5-cm diameter circle was planned due to concerns of light scatter increasing the fluence rate.

Intraoperative Robotic Exposure and Photodynamic Therapy Considerations

Traditional laryngoscopes have been used for surgical exposure of the oropharynx for transoral laser microsurgery. Not only is exposure incomplete, but surgical manipulation is limited by the sight line of the exposure. As optimal photosensitizer activation is dependent on achieving uniform light delivery, it is important to gain adequate exposure of the oropharynx in three-dimensions. We sought to determine whether the transoral robotic system could facilitate adequate exposure and visualization with safe illumination of the TORS bed.

The robotic system provides guidance to the surgeon using a stereoscopic camera with a built in xenon arc lamp light source. This source illuminates an area larger than the treatment area, approximately a 10 cm diameter circle in this case. The measured light output at the distal end of the camera assembly of 1.6 W at its highest power setting. Much of the power falls in a region where Photofrin is highly absorbing. Based on the published excitation spectra of protoporphyrin IX (2), one of the principal components of Photofrin, we estimated that at full power, this was equivalent to approximately 4.8 W of 632-nm laser light. To reduce the unintended photosensitizer activation, we operated the source at 50% power and covered the tip of the camera assembly with a light filter cap fabricated from a deep-dyed polyester filter paper (GamColor #480, Los Angeles, CA) (Figure 2). The melting point of the filter paper is 480°F. This reduced the effective power of the source to approximately 580 mW. We estimated that this contributed an additional equivalent dose of approximately 3.5 J/cm² over the 8 minutes during which it illuminated the field during the procedure.

Oral exposure was gained using a Crow-Davis retractor. Saline soaked white packing was used throughout the oral cavity and left oropharynx to expose only the right oropharynx. One robotic arm with the magnifying light and 3-D endoscope plus two additional robotic arms with Maryland dissector endowrist instruments were inserted with the left-sided arm holding the microlens laser and the right-sided arm second holding a light fluence probe (Figure 3). The microlens was angled such that the aim beam encompassed the surgical bed.

The microlens (Model FD, MedLight SA, Switzerland) was attached to a Cerelas Series GaAlAs 4 W diode laser (Biolitec, Inc., East Longmeadow, MA) emitting a peak wavelength of 632 nm and 90% of the power within 629–635 nm. The fluence and fluence rate was measured at the center of the treatment field demonstrating a stable rate of light delivery. Due to the scattering effects of the illuminated geometry, the cumulative fluence measured in the middle of the treatment field was 356 J/cm² with a mean fluence rate of 557 mW/cm² that was very stable over the treatment time.

Postoperative management included the use of standard analgesics and light precautions limiting exposure of skin and eyes to direct sunlight or bright indoor light. The location of the pulse oximeter was changed every 15 minutes. Postoperative fiberoptic examinations were abbreviated with the power output reduced. Follow-up examination within the first 4 weeks demonstrated mucositis limited to the treatment area only (Figure 1). No adverse events were noted.

Currently, the application of head and neck PDT remains limited to anatomic sites where adequate exposure is readily obtained such as the oral cavity and glottic larynx. Adequate exposure necessitates not only visualization of the target but the ability to expose the mucosal surface perpendicular to the microlens avoiding shadows that would result in ineffective photosensitizer activation. It also necessitates the ability to then administer the photoactivating light in a stable manner. Exposure of the oropharyngeal mucosa has traditionally been limited by its anatomy even under general anesthesia with traditional laryngoscopes. Hence, the conclusion that the TORS may facilitate excellent three-dimensional visualization with safe, accurate and stable delivery of PDT to the oropharynx offers the potential to extend the application of PDT to a site previously limited by achieving adequate exposure. A 5-fold increase in the fluence and fluence rate due to the integrating sphere effect of the oropharynx anatomy was observed.

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Figure 1. Photofrin® Photodynamic Therapy in the Right Oropharynx

Figure 1A demonstrates the transoral robotic surgical (TORS) bed in the right tonsil and tongue base (B). Follow-up at 1 week demonstrated evolving mucositis limited to the tonsil surgical bed and midline mucosa (C) and the right lateral oropharyngeal wall and tongue base TORS bed (D). At week 3, the mucositis continued to be limited to these areas (E and F).

Figure 2.
GamColor[®] Filter Cap Placed Over the Robotic Light Source.

Figure 3. Transoral Robotic Arms Administering Photofrin® Photodynamic Therapy in the Right Oropharynx

Figure 3A demonstrates the arrangement of the robotic arms and the light source with the laser source on the patient's left side and the fluence probe on the patient's right side (3B).

Figure 4. Transoral View of the Right Oropharynx Treated with Photofrin® Photodynamic Therapy

Figure 4A demonstrates the laser light source with the fluence probe placed in the middle of the treatment field (4B).