TRANSORAL ODONTOIDECTOMY

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Received, March 18, 2004.
Accepted, December 13, 2004.

ONLINE DIGITAL VIDEO

THE TRANSORAL APPROACH for odontoidectomy is described in detail, and the operating room setup and surgical positioning are demonstrated. We also discuss our methods of retractor placement and techniques for optimal surgical exposure. The microsurgical technique used for decompression is presented in detail. The surgical pearls and pitfalls of transoral odontoidectomy, learned from a 70-case experience, are described and illustrated.

KEY WORDS: Craniocervical junction, Decompression, Odontoidectomy, Transoral surgery

Neurosurgery 56:1045-1050, 2005 DOI: 10.1227/01.NEU.0000158202.60442.FA www.neurosurgery-online.com

The transoral approach has been used to decompress the craniocervical junction with varying degrees of success by numerous authors over the past half-century. The indications for transoral resection of the odontoid process include nonreducible bony compression of the spinal cord or soft tissue pannus, causing severe ventral compression and resulting in spinal cord contusion with rapidly progressive myelopathy. Ventral soft tissue pannus causing compression without cord contusion or rapidly progressive myelopathy may also be treated with a posterior decompression and fusion, which typically leads to a reduction of the pannus size over time.

The transoral approach has been modified by various authors, including Menezes (14–16), Crockard (1–5, and Sonntag's group (12), to improve exposure and reduce complications. In this article, we outline the pearls and pitfalls of the transoral technique using lessons learned from the experience of the senior author (RWH).

OPERATIVE CONSIDERATIONS

Patients with nonreducible craniocervical junction bony compression are candidates for transoral odontoidectomy. The body habitus of the patient must be taken into account before embarking on this procedure. The patient should be able to open his or her mouth widely enough to accommodate the transoral retraction systems. In our experience, the minimum oral working channel diameter necessary to perform an odontoidectomy is 3 cm. The oral cavity must also be in a healthy condition.

PATIENT POSITIONING

Intraoperative positioning of the patient is critical to achieving success with the transoral approach. Before intubation, patients are positioned on the operating table, while awake, with the head in extension on a horseshoe headrest in the position required for surgery. We position the patients while they are awake to ensure that no new neurological symptoms occur with head extension. Subsequently, fiberoptic oral intubation is performed with an armored endotracheal tube while the patient is awake.

Prophylactic tracheostomy is performed only in patients who have Down's syndrome or patients with small oral apertures (approximately 3 cm, depending on the rostral-caudal extent of the pathology to be decompressed). These patients have both redundant posterior pharyngeal wall tissue and a decreased ability to coordinate their pharyngeal musculature after odontoidectomy.

Before surgery is started, 2,000,000 U of penicillin G or 600 mg of clindamycin is administered to patients. Dexamethasone may also be administered before surgery to decrease neural and airway edema.

In patients with severe myelopathy, we consider using somatosensory evoked potentials and/or motor evoked potentials. When we used neuromonitoring, we chose to obtain a preoperative baseline study before making an incision.

If necessary, cranial traction may be used to optimize anatomic reduction of the craniocervical junction (*Fig. 1*). However, traction is not necessary for most patients.

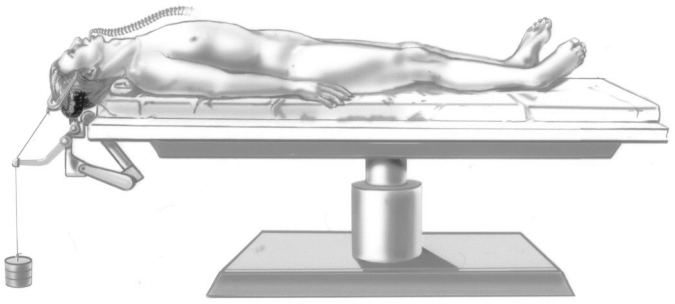

FIGURE 1. *Artist's illustration of patient positioning using a horseshoe headholder. Cranial traction may be used to optimize anatomic reduction of the craniocervical junction, if necessary.*

OPERATING ROOM SETUP

To maximize ergonomics for a right-handed surgeon, the patient is positioned with his or her left side toward the anesthesiologist. The endotracheal tube is placed in the midline of the mouth. The C-arm fluoroscope is positioned to obtain cross-table lateral cervical x-ray views. The surgeon stands behind the patient, and the scrub nurse is positioned to the right side of the patient. The operating microscope base is positioned to the left-hand side of the surgeon (*Fig. 2*).

SURGICAL TECHNIQUE
(*see video at web site*)

A Spetzler-Sonntag retractor is placed with an appropriate tongue blade to retract the tongue and endotracheal tube inferiorly. Care is taken to avoid trapping the tongue against the teeth.

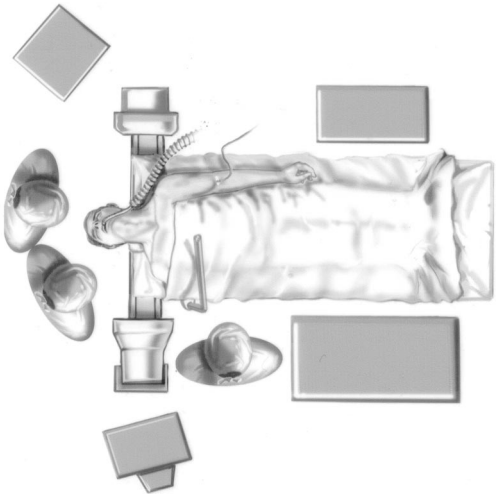

FIGURE 2. *Artist's illustration of operating room setup. To maximize ergonomics for a right-handed surgeon, the patient is positioned with his or her left side toward the anesthesiologist. The C-arm fluoroscope is positioned for lateral cervical x-ray views. The surgeon stands behind the patient, and the scrub nurse is positioned to the right side of the patient. The operating microscope base is positioned to the left of the surgeon.*

The retractor is opened as widely as possible to allow maximum exposure of the posterior pharyngeal area (*Fig. 3*). The anesthesiologist administers agents that create neuromuscular blockade to allow for wider mandibular opening.

Once the Spetzler-Sonntag retractor is in place, a red rubber catheter is placed through one of the nares and is sutured to the uvula using 4-0 Vicryl suture (Ethicon, Inc., Somerville, NJ) (*Fig. 4*). The catheter is then pulled up through the nose, and the uvula and soft palate are retracted superiorly; this retraction improves exposure of the upper portion of the posterior pharyngeal wall overlying the tip of the odontoid and prevents secretions from running into the incision. We think that this is a critical step because this maneuver allows us to avoid making soft palate incisions on the majority of patients. It is the incision of the soft palate that commonly contributes to swallowing difficulties and dysphonia in some patients. The superior soft palate retractor on the Spetzler-Sonntag system is applied after the uvula is retracted superiorly to provide even greater superior exposure (*Fig. 5*).

The posterior pharynx is then infiltrated with 1% lidocaine with epinephrine. Subsequently, lateral fluoroscopy is used to identify the area of the posterior pharyngeal mucosal wall overlying the odontoid process. The incision is typically 1.5 to 2 cm in length and is carried through the posterosuperior pharyngeal constrictor muscle in the midline raphe (*Fig. 6*). Our initial incision is shorter than what is ultimately needed for the odontoidectomy because the retractors that are subsequently placed tend to extend the rostrocaudal length of the incision when they are opened. Once the incision has been created, we are careful to not touch the remainder of the oral cavity outside of the incision. We avoid tracking secretions and oral bacteria into the incision with this "no touch" oral cavity technique.

A Crockard self-retaining retractor is then placed in the midline pharyngeal incision and spread laterally to expose the anterior arch of C1. We then use the bovie to skeletonize the anterior surface of the arch of C1 (*Fig. 7*). The fluoroscope is used to confirm anatomic landmarks. The use of image guid-

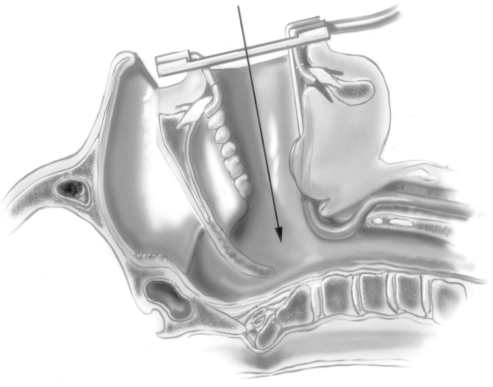

FIGURE 3. *Artist's illustration of the Spetzler-Sonntag retractor placement. The tongue and endotracheal tube are retracted inferiorly. Care is taken to avoid trapping the tongue against the teeth. Note that the soft palate and uvula are still obstructing the surgeon's view of the dens (*arrow*).*

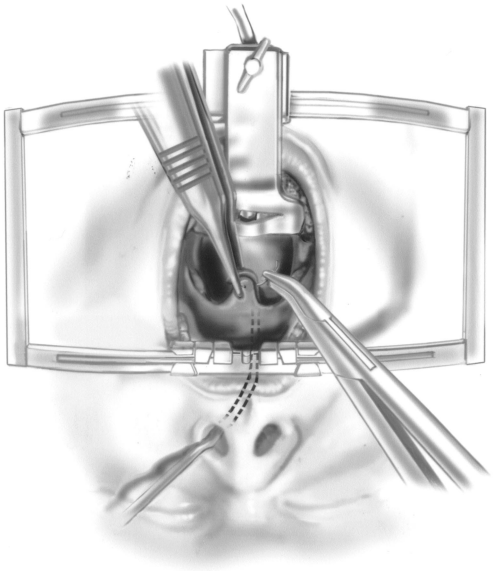

FIGURE 4. *Artist's illustration from the operating surgeon's view showing the placement of a red rubber catheter through one of the nares and the attachment of the distal end to the uvula with a suture. Retraction of the red rubber catheter allows for elevation of the uvula and soft palate.*

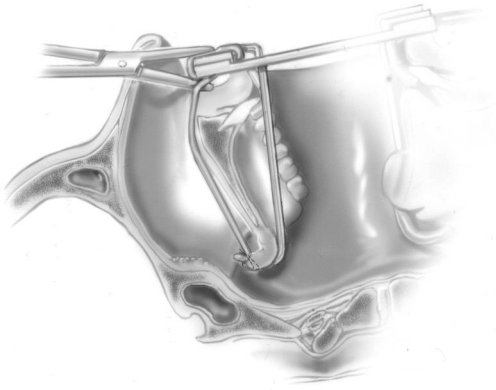

FIGURE 5. *In this sagittal illustration, the uvula is retracted superiorly by tractioning the red rubber catheter through the nare. The red rubber catheter is secured to the Spetzler-Sonntag retractor after the uvula has been retracted. The soft palate blade of the Spetzler-Sonntag retractor is then attached and used to push the soft palate superiorly, allowing for direct access to the posterior pharyngeal wall overlying the odontoid process.*

ance is optional, and in most cases we do not use computerized neuronavigational systems.

Once the arch of C1 has been exposed (*Fig. 8*), we identify the midline and drill and remove the anterior arch of C1 to expose the anterior portion of the odontoid process. The anterior C1 arch removal should be wide enough to expose the shoulders of the odontoid process. This typically requires the removal of two-thirds of the anterior arch of C1. We examine the preoperative computed tomographic scans to ensure that

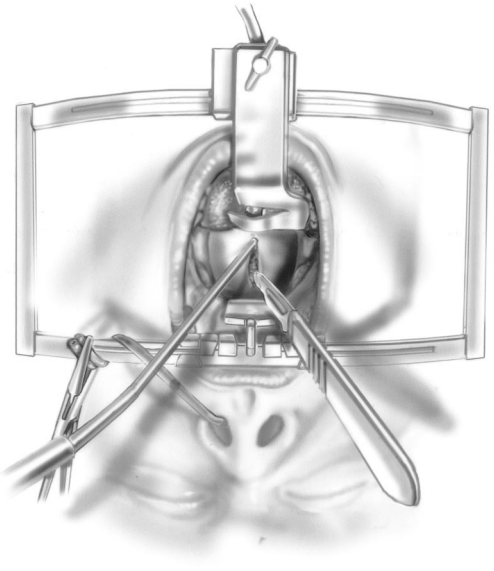

FIGURE 6. *Illustration of surgeon's view after the placement of the Spetzler-Sonntag retractor blades. The soft palate has been elevated by the superior blade. The red rubber catheter has been tractioned and is secured to the Spetzler-Sonntag frame with a clamp. A linear incision is then created in the midline posterior pharyngeal wall overlying the area of the odontoid.*

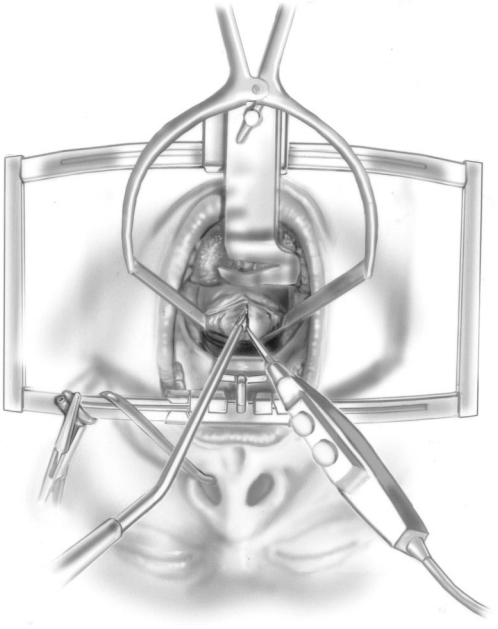

FIGURE 7. *Artist's illustration from the operating surgeon's view. The Crockard retractor is placed in the pharyngeal incision and spread laterally to expose the anterior arch of C1. The bovie is used to skeletonize the anterior arch of C1.*

there are no variations in the normal anatomic course of the vertebral artery in the foramen transversarium of C1 and C2.

Once the odontoid process has been exposed, we take an angled curette and detach the apical and alar ligaments at the top

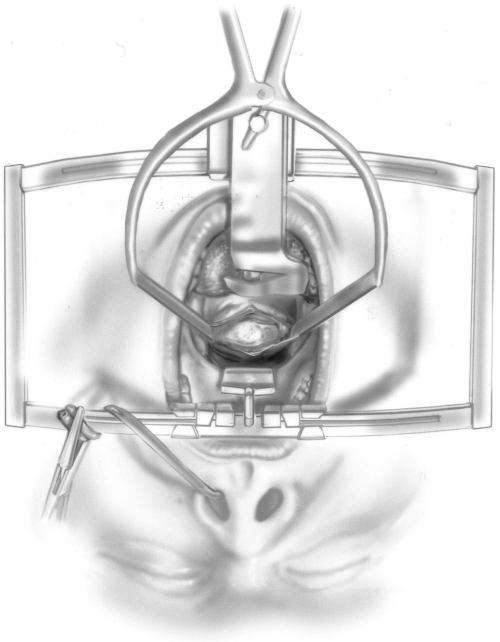

FIGURE 8. *Artist's illustration from the surgeon's view showing the exposed anterior arch of C1, allowing drilling of the anterior C1 arch to commence.*

of the odontoid process. Fluoroscopy is helpful in identifying how far posterior the angled curette can be placed without violating the spinal canal. These ligaments act as a tether and prevent removal of the tip of the dens if they are not cut. Removal of these ligaments at the apex of the dens establishes the superior boundary for bone removal and allows for subsequent resection of the top of the odontoid process. In patients with significant basilar invagination, accessing and removing these ligaments can be difficult; traction is used in these cases to gently pull the top of the odontoid process inferiorly.

Once the ligaments have been detached, we perform a "top-down" removal of the odontoid process by drilling the dens using an eggshell drilling technique with the Midas Rex AM 8 drill bit (Medtronic, Fort Worth, TX) (see video at web site). The AM 8 drill bit has a smooth tip, which tends to not catch and tear soft tissue. This drill can be used to drill all the way through the odontoid process up to the transverse ligament.

We do not disarticulate the odontoid at its base with the drill and allow for a free-floating odontoid fragment. Such a "bottom-up" drilling procedure allows the odontoid to float freely and does not provide resistance to the drill bit for further removal of the bone. The "top-down" drilling technique ensures that the apex of the dens, which often causes significant spinal canal compromise, is removed first. The surgeon can than proceed in a stepwise fashion (in a superior to inferior direction) to remove the remainder of the dens without leaving floating bone fragments behind. In cases in which the apex of the dens cannot be reached with the drill tip, we use Kerrison rongeurs and/or curettes to reach around the top of the dens and bite away the bone.

In patients with rheumatoid arthritis or with fibrocartilaginous lesions of the odontoid area, soft tissue pannus is encountered typically once the bone of the dens has been removed. We remove some of the soft tissue pannus. However, we are not as aggressive now with our pannus removal as we were in the past. Several studies have shown spontaneous resorption of the soft tissue pannus after posterior fixation (11, 19). Since we tend to perform a posterior fixation for almost all patients, we do not think it is mandatory to remove all of the soft tissue pannus. We remove all loose fragments of soft tissue pannus but do not try to peel the deep layers from the surface of the dura. Aggressive removal of soft tissue pannus risks injury of the underlying dura and potential leakage of cerebrospinal fluid (CSF). CSF leakage in the setting of the transoral odontoidectomy may result in meningitis, which can be fatal.

Once we think that we have achieved an adequate removal of bone and pannus, we inject iohexol dye into the resection cavity and obtain a lateral fluoroscopic x-ray to confirm the extent of our decompression. The spread of the dye helps to reveal any remaining remnant of the dens. In cases in which neuronavigation is used, the image guidance system is helpful in identifying any remnants of the dens. If we are pleased with the bone removal, we then proceed with closure.

The posterior pharyngeal mucosa and muscle are closed by reapproximating the muscle and mucosa with interrupted 3-0 chromic suture in a single- or double-layer fashion. The posterior pharynx is irrigated with a small amount of antibiotic solution. Excessive oral irrigation may allow fluid to enter the airway and lungs, so only the incision is irrigated, rather than the entire oral cavity.

The nasal red rubber catheter is removed. The uvula returns to its original place. To allow for eating after the operation, a Dobhoff feeding tube is passed through one of the nares and into the esophagus while the Spetzler-Sonntag retractor is still in place in the mouth. The Dobhoff tube is stitched to the lateral wall of the nostril to prevent accidental dislodgement. The retractor systems are then removed, and the tongue and lips are inspected. Cortisone cream is typically applied to the tongue and lips to reduce postoperative swelling. The tongue is massaged to restore circulation. Typically, we do not release the tongue retractor during the procedure because we are able to perform the operation within 90 minutes. There is occasionally edema of the tongue after the surgery, but this resolves in most patients within 2 or 3 days.

Previous studies have demonstrated the instability created by the removal of the odontoid process (6, 7). We typically perform a posterior stabilization procedure on the same day as the transoral odontoidectomy. This is performed without changing the endotracheal tube. The patient is fixated in skull clamps and positioned prone onto chest rolls on a separate operating table for the posterior portion of the procedure. For patients with significant basilar invagination or with occipitocervical instability, we perform occipitocervical fusion. For patients without significant basilar invagination and with only C1–C2 instability, we prefer to perform transarticular screw fixation or C1 lateral mass screws with C2 pars screw con-

structs (9, 10, 13, 17, 18). All of our posterior fusions incorporate iliac crest autograft or rib autograft.

Once the patient has undergone the posterior stabilization procedure, the patient is monitored in the intensive care unit. We typically leave all of our patients intubated in intensive care for 2 to 3 days. Patients are extubated only after a cuff leak (breathing around a deflated endotracheal cuff) is confirmed by the anesthesiologist in the intensive care unit on postoperative Day 2 or 3. The anesthesiologist typically removes the endotracheal tube over a tube changer, which is left in place for 1 hour. The tube changer allows for easy reintubation, if necessary.

COMPLICATION MANAGEMENT

CSF Leaks

CSF leaks encountered during the course of a transoral surgery have potentially devastating consequences. Meningitis, caused by oral bacteria invading the CSF, and death have been reported with this complication (8). To avoid CSF leaks, we avoid the aggressive removal of the soft tissue pannus often seen in patients undergoing transoral odontoidectomy. Any loose pannus is typically removed, but we do not think it is necessary to remove all pannus up to the dura. Studies have shown spontaneous resolution of the pannus after posterior fusion in these patients.

If a CSF leak is encountered during surgery, we attempt to sew the leak closed. We then place Tisseal (Baxter Pharmaceuticals, Deerfield, IL) and a small piece of DuraGen (Integra NeuroSciences, Plainsboro, NJ) over the area of the CSF leak to seal it. We consider placing a subarachnoid lumbar drain in patients with CSF leaks. However, excessive CSF drainage paired with a lumbar drain may create a negative pressure at the pharyngeal incision, which could pull oral secretions and bacteria into the CSF pathway.

Vertebral Artery Injury

The surgeon must be cognizant of the location of the vertebral artery in relation to the planned bony resection of the arch of C1. Typically, we obtain and closely review a preoperative computed tomographic scan of the occiput to C3 to assess for any anatomic variations in the position of the foramen transversarium of C1 and C2. Occasionally, a very medially positioned foramen will be identified on these studies and the surgeon must be aware of this anatomy to avoid drilling into the foramen and risking injury to the vertebral artery. This danger is especially high in patients who have a rotatory subluxation at C1 and C2. In addition, the surgeon should be aware that the vertebral artery typically undertakes an anteromedial course at the level of the C2–C3 disc. Care must be exercised to avoid lateral dissection at the level of the C2–C3 disc.

If the vertebral artery is injured during the removal of the anterior arch of C1 or the dens, it is our practice (one patient) to pack off the bleeding with Gelfoam (Pharmacia & Upjohn, Kalamazoo, MI) and not attempt direct repair of the vessel. We then request intraoperative (if available) or immediate postoperative angiography to evaluate the vessel injury and consider endovascular obliteration of the vessel.

Spinal Cord Injury

Patients with severe myelopathy are at risk for worsening of their motor function after any spinal decompressive procedure. To minimize these risks, it is our practice to position patients on the operating table while they are awake to ensure they do not have new neurological symptoms when placed in the position for surgery. In addition, for patients with severe myelopathy, we often monitor somatosensory evoked potentials and motor evoked potentials during surgery. If there are changes, we immediately try to ascertain the reason.

In addition, we preoperatively discuss with our anesthesia staff the goal of maintaining the patient's preoperative mean arterial pressure at all times during induction and surgery. Before surgery, severely myelopathic patients typically undergo placement of an arterial line to monitor their mean arterial pressure. Avoiding hypotension in such patients is of paramount importance, as even temporary hypotension can cause cord ischemia resulting in a worsening of the neurological state.

CONCLUSION

The transoral technique is a viable and useful option in the treatment of irreducible ventral craniocervical junction bony compression. We have described the techniques that we use to obtain excellent exposure and to perform decompression while avoiding complications. There is a learning curve to this technique. The complications we have reported represent some of the potential pitfalls associated with this technique.

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Acknowledgments

We thank our teachers who taught us various nuances of the technique we have described: Alan Crockard, D.Sc., F.R.C.S., Arnold Menezes, M.D., and Volker K.H. Sonntag, M.D. We are grateful to our colleagues, Gerald E. Rodts, M.D., and Maxwell Boakye, M.D., for their insight. We also thank Regina Carder, Sherry Ballenger, Drew Imhulse, and Bill Winn for their assistance with the manuscript and figures.

COMMENTS

Mummaneni and Haid provide clear and concise descriptions and illustrations of the transoral approach for the treatment of pathology at the craniocervical junction. The authors include a thorough discussion of the indications, operating room setup, and nuances of the surgical technique. They also discuss in detail the avoidance and management of perioperative complications, as well as the potential need for posterior stabilization after transoral decompression.

In short, the authors have provided an excellent set of guidelines that, if followed, will minimize the perioperative risks of the transoral procedure and allow for excellent surgical outcomes.

Paul R. Cooper
New York, New York

The authors share with us some pearls gleaned from their extensive experience with transoral approaches to the spine. Recent advancements in the pharmacological treatment of rheumatoid arthritis have reduced the incidence of cervicomedullary compression from exuberant pannus formation. Nevertheless, this approach remains critical for accessing anterior pathology at the craniocervical junction, and this article serves as an excellent review of the technique.

Michael Y. Wang
Los Angeles, California

The authors nicely describe the transoral technique for removing the odontoid and associated pannus. They include several pearls, such as how to adequately retract the uvula and soft palate, and potential pitfalls, such as how to treat cerebrospinal fluid leaks or vertebral artery injury. Transoral odontoidectomy is an excellent operation for anterior decompression of the cervicomedullary junction. The authors have nicely described this technique.

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Phoenix, Arizona

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