Restabilization of the Occipitocervical Junction after a Complete Unilateral Condylectomy: A Biomechanical Comparison of Unilateral and Bilateral Fixation Techniques.

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Introduction: During transcondylar surgical approaches to tumors at the anterior foramen magnum occipitocervical instability may result from resection of the occipital condyle. Initially, patients may be able to maintain a neutral alignment in the immediate postoperative period but over time severe occipitoatlantal subluxation may occur with cranial settling, kinking of the spinal cord, and neurological injury. This clinical scenario has received very little attention in the literature. We conducted a biomechanical analysis to evaluate potential fixation constructs to prevent the progression to severe deformity in patients who require radical unilateral condylectomy during a skull base tumor resection.

Methods: Ten human cadaveric specimens (Oc-C2) underwent biomechanical testing. A complete unilateral condylectomy was performed to completely destabilize one Oc-C1 joint, leaving the contralateral joint intact. Various unilateral and bilateral occipitocervical fixation configurations were tested. Occipital fixation was achieved using a plate affixed to the occipital keel with 4mm titanium screws. Titanium screws with polyaxial heads were inserted into either the C1 lateral mass or C2 pedicle. A titanium rod was inserted to connect the screws to the occipital plate. Tested configurations included: a bilateral Oc-C1 construct, a unilateral Oc-C1 construct on the resected side, a bilateral Oc-C2 construct, and a unilateral Oc-C2 construct on the resected side. Biomechanical testing was performed to compare range of motion and stiffness between constructs under physiological loads (1.5 N-m).

Results: After complete unilateral condylectomy, bilateral fixation constructs (Oc-C1 and Oc-C2) provided more stability than unilateral constructs [up to 51% decrease in motion (p=0.001) and 122% increase in stiffness (p=0.003) for Oc-C1 fixation and up to 46% decrease in motion (p=0.004) and 149% increase in stiffness (p=0.005) for Oc-C2 fixation]. A bilateral Oc-C2 construct provided no biomechanical advantage over a bilateral Oc-C1 construct (lateral bending stiffness 1.80 vs. 1.37 N-m/deg, p=0.38; flexion-extension stiffness 2.89 vs. 1.23, p=0.08). A unilateral Oc-C1 construct decreased motion up to 73% compared to the destabilized state, but produced the least stiffness of all constructs tested.

Conclusion: Patients who undergo a radical unilateral condylectomy require close surveillance for occipitocervical instability. A bilateral Oc-C1 construct provides suitable biomechanical strength and will enable preservation of atlantoaxial motion. A unilateral construct decreases abnormal motion but lacks the stiffness of a bilateral construct. However, given that in clinical practice most patients undergo a partial condylectomy and only a small proportion of patients develop instability, a unilateral construct may provide enough support to prevent progression to severe occipitocervical subluxation in most patients.
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Introduction:

• Transcondylar surgical approaches are performed by neurosurgeons to access pathology at the anterior foramen magnum and skull base

• Drilling the occipital condyle increases surgical access and decreases working distance

• As the extent of condylar resection increases, patients are at risk for developing occipitocervical instability with kinking of the spinal cord
Introduction:

• Disrupted Oc-C1 joint may be unable to resist forces in lateral bending, leading to instability.

• Instability can present several weeks or months after surgery with a severe coronal deformity at the occipitocervical junction.

• We performed a biomechanical analysis of fixation constructs that could be used to manage unilateral Oc-C1 joint disruption.
Methods:

- Biomechanical investigation
- 8 human fresh-frozen head-neck specimens isolated Occiput-C3
- Performed a complete unilateral disruption of occipital condyle via the far lateral transcondylar technique
- Compared unilateral and bilateral fixation constructs
- Tested stiffness in the pre-destabilization and post-restabilization states
Methods:

• Instrumentation:
  • C1 lateral mass or C2 pedicle screws
  • Occipital keel plate
  • Titanium rods

• Fixation construct comparison:
  • Oc-C1 unilateral
  • Oc-C1 bilateral
  • Oc-C2 unilateral
  • Oc-C2 bilateral
Results:

No biomechanical advantage in lateral bending for bilateral Oc-C2 vs. bilateral Oc-C1 construct.

Bilateral Oc-C2 construct was stiffer in flexion extension and axial rotation than bilateral Oc-C1 construct.

Lateral bending: 1.80 vs. 1.37 Nm/° (p=0.17)
Flex-ex: 2.93 vs. 1.23 Nm/° (p=0.0031)
Axial rotation: 3.62 vs. 1.21 Nm/° (p=0.052)
Bilateral constructs were stiffer than unilateral constructs.

Bilateral Oc-C1 construct had 51% less motion (p=0.001) and 122% more stiffness (p=0.003) than unilateral Oc-C1 construct.

Bilateral Oc-C2 construct had 46% less motion (p=0.004) and 149% more stiffness (p=0.005) than unilateral Oc-C2 construct.
Construct comparison

For lateral bending, the difference in magnitude between bilateral and unilateral constructs was statistically significant but small.

All constructs were biomechanically stiffer than intact specimens without instrumentation.
Conclusions:

- Patients with unilateral Oc-C1 disruption from a condylectomy can present with a delayed coronal deformity at the occipitocervical junction.
- Unilateral Oc-C1 construct is biomechanically appropriate and is motion-preserving.
Future Directions

• Cyclical fatigue testing is needed to determine long-term construct durability

• Given that only a few patients develop instability if a partial condylectomy is performed, is there a role for using a unilateral fixation construct in patients who would otherwise be braced?

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