Conclusions

Methods and Materials

The costal cartilages of porcine rib were obtained from a local packing house. The third and fourth costal cartilages, which were harvested from the central core of the rib, were cut into slices of 1 mm, 2 mm, and 3 mm thicknesses. Each rib was cut along the concave and convex sides of the rib, yielding a total of 15 samples per thickness.

Costal cartilage is relatively abundant, rigid, and can be carved into a variety of shapes. Specifically, the costal cartilage is relatively abundant, rigid, and can be carved into a variety of shapes. The cartilage slices were cut and positioned as a dorsal graft. The degree of warping was calculated using an arc tan method (Figure 5). Measurements were obtained from the photographs using a graphics editing program (Photoshop CS6, Adobe Systems Inc., San Jose, CA).

The initial curvature after cutting a flat cartilage slice provides valuable information regarding the potential for warping. Specifically, the initial curvature, defined as the angle formed by the long axis of the rib and the plane of the cartilage slice, was measured using arctan (2 x (H/L)), where H is the height and L is the length of the slice.

Results

Effect of Slice Dimensions on Warping

Regardless of dimension, all cartilage slices warped during the entire 24 hour evaluation period, with the majority of warping occurring within the first 30 minutes (Figure 6). Overall, specimens with a smaller thickness warped more than specimens with a greater thickness (Figure 7). Specifically, the mean amount of warping at 30 minutes after carving for slices of 1 mm, 2 mm, and 3 mm thickness was 8.8°, 7.1°, and 6.2°, respectively. In addition, slices with a smaller width significantly warped more than slices with a greater width (Figure 8).

Effect of Initial Curvature on Overall Warping

For all thicknesses, there was a positive correlation between degree of initial curvature (°) and amount of warping 24 hours after carving (Figure 9). The correlation was increased in samples with smaller thicknesses. Using a linear regression, the slopes for slices having 1 mm, 2 mm, and 3 mm thickness were 0.65, 0.29, and 0.13, respectively (R² values were 0.61, 0.60, and 0.52, respectively).

Comparison of Warming between Concave and Convex Slices

At 24 hours after carving, there was significantly increased curvature in slices from the concave surface of rib as compared to slices from the convex surface. The mean curvatures at 24 hours for concave slices having thicknesses of 1 mm, 2 mm, and 3 mm were 8.2°, 8.3°, and 8.6°, respectively. In comparison, the mean curvatures for the convex slices were 4.8°, 3.1°, and 5.2°, respectively.

Discussion

Costal cartilage is relatively abundant and rigid, which makes it a valuable graft source for nasal reconstructive surgeries. However, the inherent tendency of costal cartilage to warp can make the use of these grafts challenging and unpredictable. In order to better characterize costal cartilage warping, this study evaluated the effect of graft thickness, width, and initial curvature, and harvest location on the degree of warping over a 24 hour period. Grafts specifically from the peripheral region of the rib were examined because cartilage from this region typically undergoes a greater amount of warping, and thus trends are more evident. Cartilage slices with greater thicknesses and widths yielded more stable grafts that warped less. Although this data improves our understanding of costal cartilage warping, it is unlikely to significantly alter graft design during nasal reconstructive surgeries. For example, the thickness of a graft is often limited to a specific size in order to maintain aesthetics and avoid narrowing of the airway. However, in contrast to graft thickness, there is potentially more flexibility with increasing the graft width, such as would be possible in lateral crural strut grafts. Another important caveat with graft thickness is that the soft tissue envelope must also be considered. It is likely that as graft thickness is decreased, warping is more effectively counteracted by the tension of the overlying soft tissues.

The majority of warping for all experimental groups occurred within the first 30 to 60 minutes, which is similar to findings in prior studies. This is a feasible time period to store the graft in saline during operative cases, with the benefit of significantly decreasing warping after graft implantation. The initial curvature after cutting a flat cartilage slice provides valuable information regarding the potential for warping. Specifically, an increased amount of initial warping was associated with increased warping over time. Therefore, extra prudence should be used when grafts are noted to have a high degree of warping prior to implantation. Ideally, these grafts should be avoided. However, no other options are feasible, then these grafts should be advantageously placed. This involves positioning the graft so that continued warping would be in a more favorable direction. In addition, maneuvers such as monolateral and cross hatching may be useful for these grafts that are expected to have increased warping.

The final curvature at the end of the 24 hour evaluation period was less in grafts obtained from the convex region of the rib as compared to grafts obtained from the concave region. This is reasonable, considering that cartilage slices from the convex region of the rib start to curve away from the perichondrium. Then over time, the cartilage warps and curves in the opposite direction towards the perichondrium as described by Gilles. Since the initial curve and direction of warping are in different directions, the final shape is straighter.

References