·综　　述·

皮层可塑性对人工耳蜗术后言语康复效果的研究进展*

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［摘　要］ 人工耳蜗植入（CI）是治疗感音神经性听力损失的最佳手段之一，能显著改善听觉言语能力，但不同个体之间存在明显差异。皮层功能研究是 CI 术后听觉言语能力康复效果差异的关键，该文从皮层可塑性分类、自适应及跨模态可塑性与 CI 术后效果的关系等方面对近年来的文献做一综述，以期为个性化康复方案的制定提供思路。

［关键词］ 听力损失；　人工耳蜗植入；　言语康复；　皮层可塑性；　综述
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Research progress on the influence of cortex plasticity on auditory speech rehabilitation effect after cochlear implantation*

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［**Abstract**］ Cochlear Implantation (CI) is one of the best treatments for sensorineural hearing loss and can significantly improve auditory and speech abilities, but there are significant differences between individuals. The study of cortical function is the key to the difference in the rehabilitation effect of auditory and speech ability after CI. This paper reviews the literature in recent years from the aspects of cortex plasticity classification, adaptive and cross-modal plasticity and the relationship between CI postoperative effect, so as to provide ideas for the formulation of personalized rehabilitation programs.

［**Key words**］ Hearing loss;　Cochlear implantation;　Speech rehabilitation;　Cortical plasticit;　Review

人工耳蜗是一种将声音信号转变为电信号的装置，可绕过病变耳蜗直接向听神经传递电刺激，恢复或重建植入者听力[1]。人工耳蜗植入（CI）是目前有效治疗重度、极重度感音神经性聋的主要手段之一[2]。据统计，目前全球已开展 CI 手术超过 70 万例，我国每年新增符合人工耳蜗手术适应证的耳聋患者超过 1 万例[3]。尽管 CI 手术可以大幅度提升患者生活质量，但植入者听觉言语能力（尤其是复杂条件下的言语识别能力）仍然存在明显的个体差异[4]。目前，认为听觉皮层可塑性是影响患者 CI 术后预后的关键因素[5]。本文就皮层可塑性对 CI 术后言语康复效果的相关研究进展做一综述。

1　皮层可塑性

大脑可塑性是指大脑在面临环境变化时不断适应和改变其结构或功能的能力[6]，其可分为自适应可塑性和跨模态可塑性 2 种。前者是中枢皮层适应外界对应的感觉刺激而不断发育的过程，如婴幼儿听觉皮层受到声音刺激后逐渐发育成熟，或听力损失儿童听觉皮层适应人工耳蜗传入的听觉电刺激过程[7]。跨模态可塑性是指当某一感觉刺激被剥夺后，其他感觉刺激会侵占被剥夺感觉刺激的相应中枢皮层，如听觉剥夺后会导致大脑的结构和功能发生改变，出现视觉刺激跨模态激活听觉皮层的现象，或视觉剥夺后出现听觉刺激跨模态激活视觉皮层现象[6-7]，这种跨模态重组可认为是大脑为代偿失去的感觉能力而采取的一种应对措施。

2　自适应可塑性与 CI 术后效果的关系

听觉系统在胎儿时期发育，听觉皮层的自适应可塑性促使出生后外界听觉刺激帮助听觉系统发育成熟[8]。CI 术后更多的听觉刺激到达听觉皮层，听觉皮层的自适应可塑性促使听功能改善，帮助听障患者听觉康复[7]。

听觉皮层可塑性存在敏感期，即听觉发展的最佳时间窗口[9]，若在此阶段发生听力损失会严重影响听

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觉及言语功能的发生、发展[10]；相应的，如果耳聋患者能够在特定的窗口内重建或恢复听觉刺激，其听觉言语功能有很大概率恢复至同龄健康水平[11-12]。其原因可能是出生时听觉皮层具有最大的神经可塑性，听觉信号的输入有利于皮层的发育，随着时间的推移，这种可塑性会降低[13]。

目前人工听觉领域普遍认为，耳聋患者接受 CI 的年龄与其术后言语功能恢复密切相关[14-15]。皮层听觉诱发电位（CAEP）的 P1 波潜伏期可作为评估中枢听觉系统发育程度的指标[16]，P1 潜伏期越短，表示听力功能越好。SHRAMA 等[16]观察到在 3 岁半之前接受 CI 的语前耳聋儿童，其 P1 波潜伏期在术后 6～8 个月内迅速缩短，达到同龄健康儿童水平。3 岁半是听觉传导通路发育的关键期，再次关键期内行 CI 能够有效刺激大脑皮层听觉皮层发育。王兴龙等[17]发现，P1 波潜伏期在出生后 42 个月龄前变化最迅速，认为该阶段前行 CI，术后听觉可在短时间内快速发育到同龄健康儿童水平。YANG 等[18]研究表明，对于严重先天性听力障碍儿童在 1 岁前接受 CI，其言语康复效果更好。DORMAN 等[19]认为超过 7 年以上听觉剥夺的儿童，即使之后经过多年的听觉刺激，P1 波潜伏期也难以恢复正常。MCCONKEY 等[20]发现，与 7 岁及以上儿童相比，4 岁之前 CI 的儿童表现出明显更高的语言感知得分和更好的语言技能。言语发展的关键期在出生前 3.5 年[21]，患者耳聋的持续时间与 CI 术后言语感知能力康复的效果存在显著负相关[22]，与术后听力和口语能力呈显著正相关[21]。

3　跨模态可塑性与 CI 术后效果的关系

跨模态可塑性在语前聋及语后聋人群中都有研究证实[23]，其程度与听障程度存在相关性[24]，对机体适应环境具有积极作用。有学者发现，听障人群往往具有更优的视觉功能，以补偿听力缺陷[25-26]，在识别手语时，大脑的活动模式与正常听力者感知听觉语言时相似[27]。但对于跨模态可塑性与 CI 术后言语康复效果的关系仍然存在争议。

部分学者认为跨模态重组可通过视觉信号与新获得的听觉信号相互结合[27-28]，视觉-听觉-运动网络整合[29]，多模态语言网络的自适应活动等提高听觉功能[30]。STRELNIKOV 等[31]通过正电子发射断层扫描技术，发现 CI 术后 6 个月患者右侧视觉皮层活动与听觉词汇识别得分呈显著正相关，提示视觉皮层活动有可能预测听觉康复预后，认为在成人 CI 中，视听协同机制对于促进言语康复至关重要。一项回顾性研究比较了来自聋哑家庭（母语为手语）和听力家庭（使用手语的机会有限）的早期 CI 术后不同时间节点的听觉感知测试、言语可懂度评分和句子模仿测试的得分情况，发现母语为手语的 CI 患者在言语感知、言语产生和语言发展等方面均优于非手语 CI 患者，表明跨模态可塑性有利于 CI 患者术后言语康复，推测与视听协助机制有关[32]。ANDERSON 等[33]利用功能性近红外光谱技术（fNIRS）发现，听觉皮层内的跨模态激活反应与植入者言语理解能力呈显著正相关。STRELNIKOV 等[34]研究证实听障人群在失去听觉输入刺激后，通过大脑的代偿机制，提高了通过视觉渠道理解口语的能力。听觉皮层对视觉语言的跨模态反应并不会以牺牲该皮层对外周听觉刺激的敏感性为代价，相反这种重组反而可通过视听协调机制提高言语识别率[35]。已有学者证实，CI 患者在视听结合的实验任务中表现得更好[36-38]，故在言语康复时应鼓励视听结合训练[39]。

但部分研究表明，跨模态重组与重建听力后言语康复效果两者之间呈负相关，即二者之间存在适应性不良的可塑性效应，认为与新获得的听觉刺激必须与其他信号（如视觉信号）共同竞争有限的大脑资源，听觉皮层没有足够的区域处理听觉信息，从而限制 CI 用户的听觉言语的康复[40-41]有关。DOUCET 等[42]使用视觉诱发电位（VEPs）技术发现，言语表现差的 CI 组诱发电位（EPs）幅值更大，在大脑内呈现更广泛、更前置的分布，提示存在跨模态重组，即不利于言语康复。GIRAUD 等[43]认为早期的视觉语言输入会阻碍后期对听觉信号的正确处理，不利于 CI 患者术后听力恢复。COLLIGNON 等[44]则认为，跨模态重组程度越低 CI 术后康复效果越好。CAMPBELL 等[45]的研究发现，CI 患者视觉语言激活听觉皮层的程度与言语感知能力呈负相关，提示跨模态重组的不适应现象。CAMPBELL 等[45]在正常听力者和 CI 儿童用户中均观察到不同的 VEP 形态，其中，CI 儿童用户表现出更大的 VEP 振幅和更早的潜伏期，同时伴有包括右侧颞叶皮层在内的听觉区域的激活，这提示听觉皮层发生视觉跨模态重组，且其 VEP N1 潜伏期与噪声下的言语感知得分呈负相关，即视觉跨模态重组不利于 CI 儿童术后言语康复。

总之，听觉皮层的视觉跨模态重组是影响 CI 术后患者听力康复效果的关键因素之一，但其关系目前是存在争议的，主流观点认为其是负相关，即跨模态重组不利于 CI 术后患者言语康复。然而，随着相关领域研究的深入，这一观点似乎过于片面，因此，以上 2 种不同的观点提示我们，要充分认识两者之间的关系，还需要进一步开展相关研究。

4　小　　结

人工耳蜗可以帮助绝大多数重度、极重度感音神经性聋患者恢复听力，但不同个体之间的言语康复效果差异较大，皮层可塑性被认为是解释这种差异的关键因素之一。CI 术后言语康复效果依赖于皮层自适应可塑性和跨模态可塑性。其中，听觉皮层自适应可塑能力越强，CI 术后言语康复的效果越好。探索皮层可塑性与言语康复效果之间的紧密关系及其可能存在的机制不仅有助于改善 CI 的效果，还可以为个性化康复方案制定提供指导。

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