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REVIEW/MISE AU POINT

rTMS for the treatment of tinnitus: The role of neuronavigation for coil positioning

SMTr pour le traitement des acouphènes : le rôle de la neuronavigation dans le positionnement de la bobine de stimulation

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Summary Tinnitus affects 10% of the population, its pathophysiology remains incompletely understood, and treatment is elusive. Both animal models and functional imaging data in tinnitus patients suggest that tinnitus is associated with increased neuronal activity, increased synchronicity and functional reorganisation in the auditory cortex. Therefore, targeted modulation of auditory cortex has been proposed as a new therapeutic approach for chronic tinnitus. Repetitive transcranial magnetic stimulation (rTMS), a non invasive method for modulation of cortical activity, has been applied in different ways in patients with chronic tinnitus. Single sessions of high-frequency rTMS over the temporal cortex have been used to transiently interfere with the intensity of tinnitus. Repeated sessions of low-frequency rTMS have been investigated as a treatment for tinnitus. Here, we review data from clinical trials and discuss potential neurobiological mechanisms with special focus on the relevance of the stimulation target and the method of TMS coil positioning. Different functional neuroimaging techniques are used for detecting tinnitus-related changes in brain activity. They converge in the finding of increased neuronal activity in the central auditory system, but they differ in the exact localisation of these changes, which in turn results in uncertainty about the optimal target for rTMS treatment. In this context, it is not surprising that the currently available studies do not demonstrate clear evidence for superiority of neuronavigational coil positioning. Further development of rTMS as a treatment for tinnitus will depend on a more detailed understanding of both the neuronal correlates of the different forms of tinnitus and of the neurobiological effects mediating the benefit of TMS on tinnitus perception.

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Résumé Les acouphènes touchent 10 % de la population mais leur physiopathologie reste incomplètement connue et leur traitement mal codifié. Aussi bien les modèles animaux que les données d'imagerie fonctionnelle obtenues chez des patients suggèrent que les acouphènes sont associés à une augmentation de l'activité neuronale, de la synchronisation et de la réorganisation fonctionnelle dans le cortex auditif. C'est pourquoi la modulation ciblée de l'activité du cortex auditif a été proposée comme une nouvelle approche thérapeutique dans les acouphènes chroniques. La stimulation magnétique répétitive (SMTr), une méthode non invasive de modulation de l'activité corticale, a été appliquée diversement chez des patients souffrant d'acouphènes chroniques. Des séances uniques de SMTr à haute fréquence en regard du cortex temporal peuvent réduire transitoirement l'intensité des acouphènes. L'intérêt de séances répétées de SMTr à basse fréquence a plutôt été évalué comme traitement à plus long terme des acouphènes. Dans ce texte, nous passerons en revue les données d'études cliniques publiées dans ce domaine et nous discuterons les mécanismes neurobiologiques potentiels de cette technique avec une attention particulière portée sur la question de la cible de stimulation et sur la méthode de positionnement de la bobine de stimulation. Différentes techniques de neuroimagerie fonctionnelle peuvent être utilisées pour déceler des changements dans l'activité cérébrale liés aux acouphènes. Les résultats obtenus sont convergents et mettent en évidence une augmentation des activités neuronales dans le système nerveux central auditif mais diffèrent dans la localisation exacte de ces modifications d'activité. Il en résulte ainsi une incertitude concernant la cible optimale à choisir pour le traitement des acouphènes par SMTr. Dans ce contexte, il n'est pas surprenant que les données actuellement disponibles ne démontrent pas clairement la supériorité d'un positionnement de la sonde de stimulation par neuronavigation. Le développement futur de la SMTr comme méthode de traitement des acouphènes dépendra d'une meilleure connaissance des bases neurobiologiques caractérisant les différentes formes d'acouphènes et des mécanismes d'action des effets de la SMTr sur la perception des acouphènes.

Introduction

Is there a need for better tinnitus treatments?

With a prevalence of 10% in the adult population, tinnitus is a very common symptom. Approximately one percent of the population is severely affected by tinnitus with major negative impacts on quality of life [5]. Severe tinnitus is frequently associated with depression, anxiety and insomnia [11,56], and is very difficult to treat [19]. The most frequently used therapies consist of auditory stimulation and cognitive behavioural treatment aiming at improving habituation and coping strategies. However, more causally oriented therapeutic strategies are lacking and need to be developed to relieve tinnitus and tinnitus distress.

How can tinnitus be measured?

As a pure subjective phenomenon, tinnitus is difficult to measure [55]. In general, the evaluation concerns two main items: on the one hand, the tinnitus intensity is of interest, i.e. how loud the tinnitus is perceived, and on the other hand the amount of distress, annoyance, and impact on daily living is important. Usually, the subjective tinnitus intensity is estimated by application of a VAS for intensity. Objectively quantifying tinnitus is attempted by matching or masking methods. This is achieved by offering different tones to the patient and asking what frequency and intensity best fit their tinnitus. When matching the tinnitus via a sound offered to the ear without tinnitus, the vast majority of the patients rate their tinnitus as less than 5—10 dB above hearing threshold [100]. The amount of distress that tinnitus evokes is assessed by validated self-report tinnitus questionnaires in the majority of studies.

Is tinnitus loudness related to tinnitus distress?

There is only a poor correlation between the intensity of the tinnitus as qualified by matching techniques and the degree of annoyance the tinnitus creates [31]. The fact that tinnitus intensity is poorly related to the perceived annoyance has resulted in the idea that emotional factors play an important role in the way tinnitus is perceived [36,78].

Pathophysiology of tinnitus

Do we know the neuronal correlate of tinnitus?

Our knowledge about the pathophysiology of tinnitus has enormously increased within the last years, but it is still incomplete. There is increasing evidence that there exist different forms of tinnitus, which differ in their underlying mechanisms. The pathophysiology of the different forms of tinnitus has to explain the mechanisms involved in the generation of both the auditory phantom percept and the related distress. It is assumed that tinnitus as an auditory percept is mainly due to changes in the central auditory